DATA PROCESSING

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For those thinking about

The problem of deciding whether a computer is appropriate or not: the steps necessary for the achievement of the best possible results in those cases where the answer is "Yes"

- ★ **The senior member of the staff put in charge of the investigation is made directly responsible to the Board and need have no mathematical background, scientific knowledge or academic training**

- ★ **Basic knowledge is best acquired by attending a course with at least two manufacturers of different types of electronic computing systems**

- ★ **The mumbo jumbo of the computer world is rapidly disappearing**

- ★ **But, paradoxically, it is much more difficult to use a commercial computing system effectively than it is to design and build it**

- ★ **Without proper planning a computer is the fastest way of churning out the greatest amount of nonsense in the shortest possible time**

By R. H. Williams, A.I.B.

With the experience gained in Great Britain and the United States, both successes and failures, there is now sufficient information from which to suggest the best approach to the problems that beset organizations considering the installation of a computer. Let us examine the case of a firm that has as yet taken no positive step in the matter, preferring to wait and see. The word "approach" has been used; undoubtedly, "general approach" would be better, because, in all matters relating to computers, quite small differences in the work to be performed can mean that a different approach is desirable. One can, however, state that the first task of a Board considering the matter is to appoint a senior member of their staff to be responsible directly to them for everything concerning electronic computing. This individual need have no mathematical background, scientific knowledge or academic training, but he should have a good working knowledge of the administration and organization of the company, be acceptable to all by reason of his personality and, most important, possess plenty of commonsense. He should have the full-time service of at least one assistant, preferably a young man of enthusiasm who, from time to time, has to be restrained and, having regard to the work that will result ere long, a capable and efficient secretary. In the case of a large commercial organization, this man will require more than

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installing a computer

one assistant, but the numbers should be limited—certainly not more than half a dozen in the early stages of the investigation. And obviously, since major decisions will be based on their work, none of these individuals will be placed in the positions because they are readily available; "free" people, one must admit, are usually doubtful and it is infinitely preferable that the company should be put to the inconvenience of replacing a good man who is in a responsible post than play fast and loose with something that can mean, one way or the other, an immense amount to the company's future.

Basic training

Once appointed, these people obviously require some basic training. This is best obtained by attending a course* with at least two manufacturers of electronic computing systems. The systems chosen should be ones which employ different input/output media, such as magnetic tape or punched cards plus punched paper tape. As a rule, these courses last about six weeks, and the majority of the organizers provide a confidential report on the aptitude of those participating and the knowledge they have gained.

In addition, those appointed should be allowed to call for specialist assistance relative to the particular needs of their company, either from the manufacturers of computers or from consultants specializing in computer applications. As a result of these preliminaries and a study of this journal, they should have sufficient working knowledge of computers to be able to assess that the information given to them makes sense, and be able to understand and judge what they are told.

Whatever may be thought the mumbo jumbo of the computer world is rapidly disappearing. The most important things, from the user's point of view, are to concentrate on what the computer can do in the individual business and, what is extremely difficult to decide, put first things first.

Paradoxically, it is much more difficult to use a commercial computing system effectively than it is to design and build it. This is not to suggest that there are not problems of design and development in the computer field still to be overcome, but the need now is liaison between those who design and make and those who can use and gain.

From what has been stated it is obvious that if after the investigation the company comes to the conclusion that it cannot use a computing system effectively, there will have been a considerable investment, all apparently in a negative direction. Apart from sheer cost, there has been the diversion of effort, the transfer of personnel and, in important degree, upset. But, at the worst, the whole subject has been explored, it has been made obvious to all concerned that the firm is alive and the investigation has revealed what the firm wanted to know, that is, whether the new-fangled ideas are worth while or not. As we all know, negative can be positive.

But let us assume that the initial investigations suggest that there is something worth while to be achieved. The team deputed for the task has contemplated the whole of the organiza-

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*Information regarding computer courses was given in the article "The Computing Service," pages 4 to 9 of *Data Processing*, January-March, 1959.

tion on the widest possible basis, without regard for existing departmental barriers, and it has taken as the criteria the following:—

What data are to be handled.

What the end requirement is—the aim—disregarding departmental methods and barriers.

Whether, pitching their thoughts still higher, they should seek to achieve what has not been possible in the past but, with a computer installation, may be possible now.

After committing the overall picture to a diagrammatical form the team should set about defining a major portion of the work that is repetitive and simple in character. They should aim at carrying out this portion of the work by means of a computing system, leaving suitable "ends" so that at a later date other work can be included, thus meeting the company's overall requirement.

A word of warning here: while it is desirable to transfer on to a computer as large a portion of the work as possible, this portion should not be so big as to be indigestible.

All this planning, of course, will take time. Concurrently, the team should be studying what computing systems are available and their general potentials, paying particular attention to cost, availability and reliability. Speed of operation, although important in some contexts, is, as far as commercial work is concerned, a secondary consideration. Let it be added here that without proper planning a computer is the fastest way of churning out the greatest amount of nonsense in the shortest possible time. Only significant data should be printed not all data just because the information has been provided in the past.

Choice of computer

At this stage it is appropriate to invite, say, three computer manufacturers to submit their proposals independently and then, if these proposals are generally acceptable, to discuss the merits and de-merits of each proposal with the individual manufacturer. As a result of this, it will probably be time to recommend to the Board that a chosen manufacturer should programme a portion of the work and demonstrate this work on a computing system.

It is at this stage that the team will obviously be assuming a heavy responsibility. A miscalculation in advising on the purchase of a £50 typewriter is a very different state of affairs from advising a Board to spend £200,000 on a computing system. As a safeguard, an independent management consultant might be called in to discuss the findings with the team or, alternatively, the Board itself may like to have an independent opinion on the findings of its team. Either way, obviously, it can be wise to get a second opinion.

Following a satisfactory demonstration, a firm order will be placed and all preparatory work set in hand to implement the system. This means initially employing a staff of programmers, who have to receive a more comprehensive training by the computer manufacturer than was necessary for the original investigating team.

Preparing programmes

Programming should, ideally, be done well in advance of the installation as a joint effort by the manufacturer and the intended user's own programming staff. The programmes should be tested and corrected on the manufacturer's service computer, so that when the user's own installation is delivered, the system can be put into operation as quickly as possible.

When the installation is running and working satisfactorily, the programmes will still require to be improved upon, but this should be dealt with in the light of day-to-day experience. In addition, the work which was left out of the original general plan will need to be added to the system. No doubt over a period of years most of the organization's data processing activities can be transferred to the system. This is inevitably a rather slow procedure and it is definitely advisable to make haste slowly.

Programming a computing system is relatively simple. Designing the system to cater for the hundred and one things which human beings, who operate the system, will inevitably do is not an easy task. It is imperative that the work should not be loaded in such a way as to leave little margin for safety. However effective a system may be, if one of the operators is not concentrating upon the work, then inevitably the system is going to suffer and this state of affairs has to be allowed for.

We are still at the beginning of this new evolution, and we can expect great things during the next few years. But if we are to achieve these considerable changes with as little heartache as possible, then it is essential that above all we should maintain our sense of proportion, as well as our good humour and common-sense.

Control panel of the Ferranti Pegasus computer in the Mathematical Service Section, which is responsible for the actual operation of the computer

A computer in a commercial organization

The administrative problems that had to be faced and how they were overcome

By P. G. Barnes

Having decided to install a Ferranti Pegasus computer the de Havilland group of companies was faced with the task of building up an administrative structure which would not remove any of the responsibilities of the user departments or offend their susceptibilities, yet would ensure full use of the new facilities. Once the idea of electronic computing had been accepted, the required volume of work was soon forthcoming.

In January, 1956, an order was placed by The de Havilland Aircraft Co., Ltd., for a Ferranti Pegasus computer which was delivered in September, 1957. A special department was created to organize and administer all computer operations and was given the name "Mathematical Service Section." This name provides the key to the position the computer occupies in the organization. The computer is one of the tools the section uses to implement the service. It is a servant of the mathematical section, not its master—and this is the correct context in which to regard an electronic computer. Great antipathy is often created by the very mention of the words electronic computer because of the belief that powerful machines tend to run the men, rather than the men run the machines. Hence, in introducing a computer into an organization, one of the major tasks is to convince other departments that the newly created computer section is not there to remove the responsibility for decisions from anyone, but only to help the individual in his job. In this connection it should be pointed out that it is not necessary to be a mathematician or an

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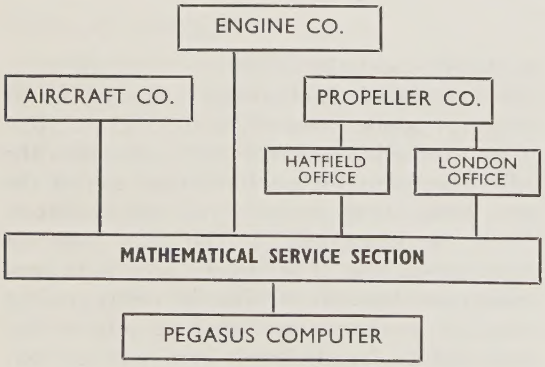
Mr. P. G. Barnes is head of the Mathematical Service Section of The de Havilland Aircraft Co., Ltd.

electronic engineer to understand the capabilities of a computer. One famous mathematician remarked succinctly that he did not understand the working of his digestive system, but this did not prevent him from eating as he certainly knew his system's limitations.

The computer was obtained mainly for technical work, but it has also been employed successfully on commercial work, and from this April it will be used to compile the weekly staff payroll. Financial savings will not be great in this particular application because data will be entered on punched paper tape and results will be recorded at 33 characters a second, also on paper tape. However, the experience gained will be considerable, and will be used to assess how the system needs to be expanded to cope with commercial work. Superannuation and staff budgets have already been calculated on the computer and recently a programme to control a spare-parts schedule was demonstrated to the production management of the company.

Between the order for the computer being placed and its delivery, many questions of organization had to be decided. The basic conditions laid down were that the machine was to be used by three companies—The de Havilland Aircraft Co., Ltd., de Havilland Propellers, Ltd., and the de Havilland Engine Co., Ltd., and was to be owned by the Aircraft Company. Each company would have its own programmers—the people who prepare the detailed operating instructions for the machine. At no time was the question of establishing one programming group to undertake the work for all three companies considered. The computer was to be made available to the Propeller and Engine companies on a service basis.



Four main groups within the de Havilland organization use the facilities offered by the Mathematical Service Section

This covered the broad organizational aspects; thus the tasks left to the Aircraft Company were to form a department to run the computer and to provide a programming section for its own needs.

Before the exact structure of the computer department could be determined, a study had to be made of the various stages through which a problem passed; this meant seeking answers to the following eight questions:—

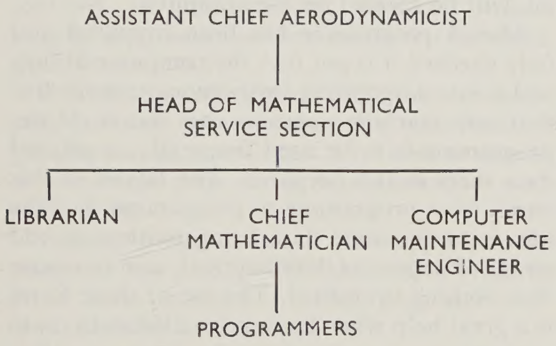
Who originates the problem?
Who decides if it is worth while solving on a computer?
Who provides the formal mathematical solution to the problem?
Who breaks down the solution into a form suitable for the computer?
Who translates the solution into a form suitable for the computer?
Who provides the data necessary to check the programme created?
Who accepts responsibility for the answers?
Who prepares the data and confirms the accuracy?

In addition, the computer department created would have to be able to cope with the following types of problem: straightforward numerical calculations, more complex problems involving numerical analysis, calculations for research where the computer would be used as a tool to help find the correct solution, and calculations where the problem had first to be arranged so that it could be done by the computer. Calculations of this last type are those at present solved by the use of tables, graphs and desk calculators.

At all times the question of who was to accept final responsibility for the answers was kept very much in mind. This question is more complex than it might appear at first sight. It was decided that, with a wide range of industrial and commercial work to be performed on the computer, it was impossible for one group of people to understand both the physical significance of the problem and the methods used on the machine to solve it. Obviously, a specialist in one branch of the company cannot usually spare the time to learn all about computers, any more than a programmer can spare the time to understand the full significance of the problems he arranges for the machine.

Hence the Mathematical Service Section's responsibilities are to advise on mathematical methods and to have executive control of the computer. In dealings with other departments, the section provides as one of its services the distribution of information on the potential uses of Pegasus and data processing methods in general and assists in developing computing and related techniques. In this the section acts in an advisory capacity. When, however, any schemes are being tried out on the computer, the section exercises executive control.

As a result of the advisory responsibilities given to the section, it is necessary that all the staff possess mathematical qualifications and, because, in addition, they will also be responsible for running the computer, they need to be fully qualified programmers. Consequently, the staff was recruited from university mathematics graduates. A chief mathematician was appointed and he was made responsible to the section head for all questions of mathematical methods and programming techniques. The section head was made responsible for the general administration of the section, maintenance staff, training schemes and liaison with other departments. In addition, a librarian was appointed to organize the day-to-day running of the computer, and a number of tape punch operators were engaged to transcribe data on to the paper tape used for computer input.


ASSISTANT CHIEF AERODYNAMICIST
HEAD OF MATHEMATICAL SERVICE SECTION
LIBRARIAN
CHIEF MATHEMATICIAN
COMPUTER MAINTENANCE ENGINEER
PROGRAMMERS

Organization of the Mathematical Service Section

Now the answers to the eight questions originally formulated could be given in a precise form.

All problems would originate from other departments.

After joint discussions, the Mathematical Service Section would decide whether or not it was worth doing on the computer.

The department originating the work should provide the formal mathematical solution.

This would be broken down and translated into the language of the computer by the Mathematical Section, who would assume full responsibility for the programme compiled.

Data and answers necessary to test that the programme performed the calculation correctly would be provided by the originating department and the Mathematical Section would carry out the check.

Responsibility for validity of results would rest with the originating department.

Accuracy of the original data supplied would be the responsibility of the originating department, although the accurate transcription of this data into punched tape would be the responsibility of the Mathematical Service Section.

Responsibilities of user departments

By making the user departments responsible both for original data and the validity of the results, full control of the work remained with those departments. But the adoption of this arrangement meant, in turn, that there had to be close contact between the Mathematical Section and all the other departments. It was also desirable that anyone having a potential problem for the computer should know something about the methods of using a computer. Accordingly a series of lectures for departmental heads was held in order to show how problems are broken down into their constituent parts ready for translation into the language of the machine.

In addition, some idea was given of the capabilities and limitations of a computer. The policy was to make knowledge of the computer freely available to all. Once the idea of electronic computing had been accepted, the required volume of work for the computer was soon forthcoming.

Eighteen months' experience of operating the computer within this administrative structure has shown that the original ideas were sound. It has also shown that when placing a new problem on the machine it is undesirable and unnecessary to adhere too strictly to the procedure just described.

Once the idea of thinking in terms of a computer has caught on in a department, the task of the Mathematical Section becomes easier because problems are then presented in a form which experience has shown to be most suitable. In these cases the Mathematical Section only has to programme the problem and accept responsibility for this part of the work.

Tape editing equipment. On the extreme right is a tape reading machine that can read two or more tapes simultaneously and confirm that they contain identical data

At present, this arrangement has not been extended to allow departments to compile their own programmes except when the problem comes within the scope of an automatic programming code, of which more will be said a little later.

However flexible the procedure, two fundamental conditions are always maintained: the Mathematical Section is responsible for programmes, the originator is responsible for the results. Acceptance of these two points requires the preparation of a document which, experience suggests, is the crux of the whole matter. This document contains a full statement of the problem. The preparation of such a document usually takes longer than the time to programme the problem for the computer.

Generally, the head of the department requesting the work discusses it with Mathematical Service Section and, if it is considered a worth while job for the computer, two people, one from each section, are given the task of preparing the full statement. This initial effort may not be in a form immediately suitable for computer programming, but the advantage of having a programmer assist in its preparation is that he gets a good grasp of the problem and, since he understands the general advantages and limitations of the computer, he can ensure that the benefits are fully exploited. If the initial statement of the problem is not suitable, as often happens when an existing manual procedure is mechanized, a second statement, based on the first, is prepared showing how the job will be tackled on the computer.

After a programme has been prepared and fully checked it is put into the computer library and a set of operating instructions compiled so that any machine operator can run it. If the programme is to be used frequently, a printed data sheet is also prepared. The layout of this varies from programme to programme, but the idea is to eliminate data being written on odd scraps of paper (as does happen!) and to ensure that nothing is omitted. The use of these forms is a great help when transcribing the data on to tape and saves many errors. In this connection, experience has shown that skilled tape punchers very seldom punch a wrong number unless the character is badly written. Indeed, most tape errors can be traced to bad presentation of data rather than to errors made by the operators.

The use of an automatic programming code requires a different approach. Such a code* is a method of writing programmes for the computer in a comparatively simple form. It can be learnt in two or three days and can be used by people with no previous knowledge of computers. The disadvantage of such a scheme is

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*See "Automatic Programming," pages 26-29, *Data Processing*, January-March, 1959.

Transcribing commercial information—in this case, superannuation fund contributions—on to punched paper tape, the medium used to feed data into the computer

that a given problem may take twice or ten times as long to run on the computer as would otherwise be the case. Its use, therefore, is confined to non-recurring problems where lengthy programming time would not be worth while economically.

Provided that the person using the automatic programming code sticks to the limitations of the scheme, all is well, but if he tries to extend or modify the code in any way, difficulties may easily arise.

Testing programmes of this type on the computer can also be difficult, and in order to avoid these troubles a skilled programmer is always available to help.

As stated earlier, a librarian is responsible for organizing the day-to-day running of the computer. Her job is to organize the queue of work waiting to go on the computer and to arrange for people to be ready to use the machine as soon as the previous operator has finished. There are four separate groups using the computer, three of them on a service basis. Regular bookings apply to these groups and the remaining time is used by the Aircraft Company.

In addition to these standard bookings, four periods of half-an-hour duration are kept each day for programme testing. There are about forty programmers using the computer, and one of the administrative problems is to keep enough time free during normal working hours so that programme testing and urgent jobs are not held up. Wherever possible, this is achieved by allowing computing runs of only 30 minutes' duration or less to be put on the machine throughout the day.

In general, the programmers are very good at estimating the amount of computer time required for a given job, but any odd time available between scheduled runs is filled in by programme testing or by taking work from the queue. The evening and night are used for long runs and for any excess work left over from the day. Programmers work one evening shift each per week and, when it is necessary, apprentices, seconded to the section for periods of three months, run the computer through the night.

De Havillands' experience is that long runs during the day are uneconomical and result in inflexibility. Programme testing is held up and urgent work delayed. Long runs are more suitable for evening and night operation and are less tiring for the operators. Incidentally, twenty or more people may operate the computer during the day, but only two are necessary throughout the night.

Operating a computer within this type of administrative structure has proved entirely successful and, as stated, there is the advantage that it does not remove any of the responsibilities of the user departments, offend their susceptibilities, or detract from their status.

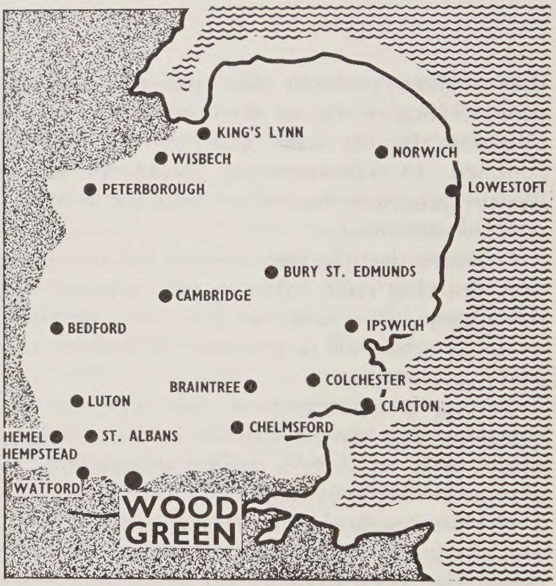
Producing 750,000 quarterly bills

Direct from meter-reading cards to the account presented to the customer: mechanization that, it is thought, will save not less than £50,000 a year: a detailed description of the Eastern Gas Board's pioneer work at its new central billing office

The system adopted by the Board is based on the fact that pencil lines drawn on the meter readers' cards can be sensed by the control mechanism of a card punch. This mark-sensing eliminates manual transcription. Hence the system conforms with that unwritten law of data processing, "All significant data should be captured at source". The other punched card equipment comprises an electronic calculator, a collator, sorters, a reproducing and mark-sensing punch, an interpreter, card punches and accounting machines.

Preparing and issuing all the quarterly bills for 750,000 customers from one central office is the aim of the Eastern Gas Board. The area administered by the Board embraces the whole of East Anglia, extends westward to just beyond Watford and goes north-west as far as Peterborough. At present about 17 per cent of the total number of accounts in this area are handled at the central billing office situated in Wood Green, London. By June, 1960, all the billing, it is intended, will be done from this one office.

About 2,000 documents are now prepared each day and, when all the work is transferred, this will rise to 10,000 a day. In the past the preparation of the bills was done at 80 local offices. Needless to say, automatic machinery is required for the major clerical task that is under way, and the office is equipped with a range of IBM punched card machines, including an IBM 604 electronic calculator on which all the necessary arithmetical work is performed.



By June, 1960, *all the quarterly bills for customers in this area will be prepared by one office situated at Wood Green*

Many advantages will accrue from this reorganization of clerical work, of which, of course, the most important is a reduction in administrative costs. At this stage, naturally it is difficult to predict with certainty the savings, but it is estimated that costs will be reduced by not less than £50,000 a year. In addition, because the work is centred in one office the system of charges made to customers will be standardized throughout the area and much more statistical data on which to base policy decisions will be made available to management. Also, quarterly bills will be distributed to customers more quickly which, in general, will mean that they will be paid earlier and, in consequence, the interest on the Board's working capital will be reduced.

Concurrently with the introduction of centralized billing, the method of reading meters is being changed. Instead of recording the meter

The central billing office of the Eastern Gas Board prepares 2,000 *documents a day. Next year this will increase to* 10,000

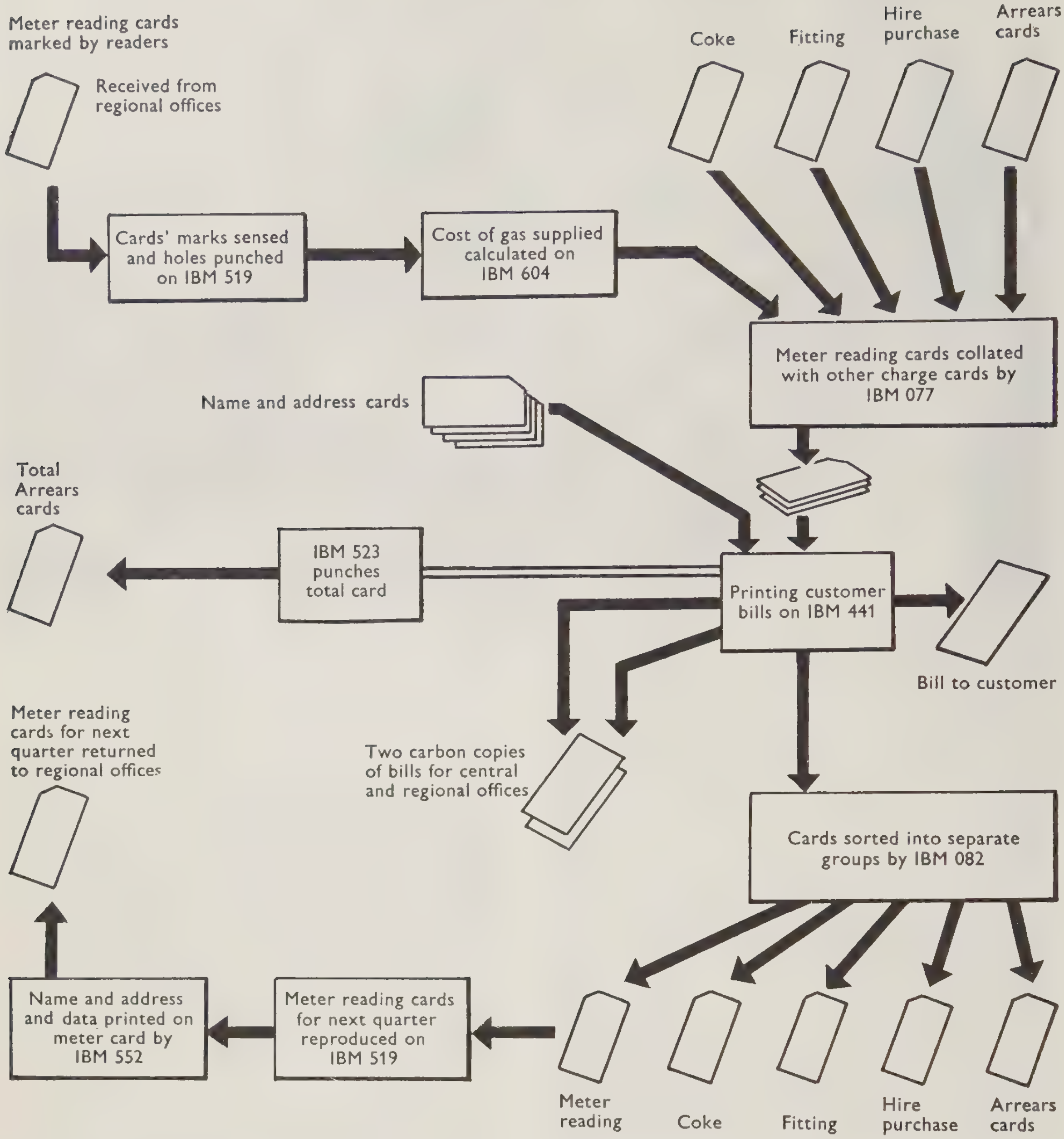
reading in writing, the meter reader marks a punched card with a soft pencil. These pencil marks are then automatically converted into punched holes in the card by an IBM 519 "mark-sensing" machine. Adoption of this method means that there is no need to employ an operator to transcribe the same information from a hand-written document on to punched cards.

The services provided to customers by the Gas Board can be listed under four headings: supplying gas, supplying coke, providing gas appliances either by direct sale or under hire-purchase agreements and the fitting and maintenance of appliances. Charges are levied for these services quarterly or intermittently depending upon the nature of the service given.

Hire-purchase charges and the bill for gas consumed are prepared once a quarter, but bills for fitting are presented for payment on completion of the work and bills for coke are given to the customer when delivery is made. If these last two charges happen to coincide with the preparation of a bill they are included on it. Obviously there are many aspects to the data processing sequence devised for preparing these quarterly bills, but in this article attention will be concentrated upon the methods used to deal with the information concerning gas supplied. Each meter reader is provided with a specially designed punched card holder that can accommodate up to 200 punched cards. There is one punched card for each meter to be read and the cards are arranged in the order in which the calls will be made. As the meters are read the cards are placed in a separate compartment at the back of the card holder. Normally one man makes from 100 to 150 calls each day.

Meter-reading card

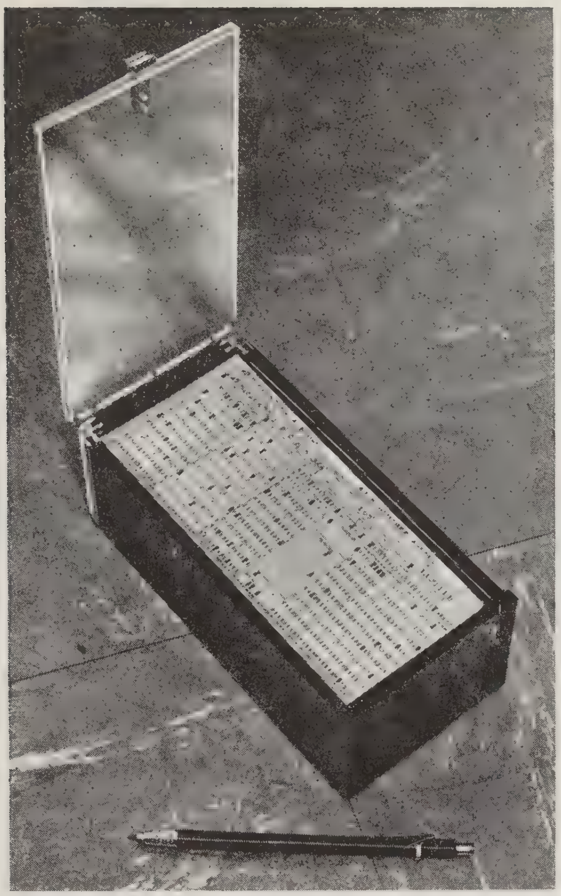
Along the top of each card—automatically printed from the cards for the previous quarter—is the account code number, and the customer's name and address. Also printed are the previous meter reading and the consumption of gas in the previous four quarters so that a comparison can be made at the time the reading is taken and any large variations in supply can be queried on the spot. In addition, the last three digits of the meter serial number are entered on the card for identification purposes, also a district code number and a sequence number specifying the order in which calls are made.


Meter reading cards marked by readers
Received from regional offices
Coke
Fitting
Hire purchase
Arrears cards
Cards' marks sensed and holes punched on IBM 519
Cost of gas supplied calculated on IBM 604
Meter reading cards collated with other charge cards by IBM 077
Name and address cards
Total Arrears cards
IBM 523 punches total card
Printing customer bills on IBM 441
Bill to customer
Meter reading cards for next quarter returned to regional offices
Two carbon copies of bills for central and regional offices
Cards sorted into separate groups by IBM 082
Name and address and data printed on meter card by IBM 552
Meter reading cards for next quarter reproduced on IBM 519
Meter reading
Coke
Fitting
Hire purchase
Arrears cards

Data processing sequence for preparing quarterly bills. Charge for gas consumed is calculated from a marked meter-reading card. This card is collated with other charge cards and from these the bill is printed automatically

A meter-reading card is shown in the illustration. Columns 16 to 30 are the ones in which the reading of the meter has to be recorded. Each meter reader is provided with a special pencil containing a thick soft lead. The grade used is 4B. With this pencil the reader strikes a heavy line through the lozenge-shaped areas containing the appropriate printed figures. In the card shown the meter reading recorded is 20984.

It will be noticed that the area covered by these columns already contains punched holes. These holes record information not concerned with the actual meter reading—in point of fact, they record statistical data. It will also be noted that the lozenge-shaped blocks which have to be marked by pencil are situated between the lines of punched holes. Consequently, when the marks are sensed by the IBM 519 the punched



Each meter reader is provided with a special holder containing the cards arranged in the order in which the calls are to be made. A 4B pencil is used to record the meter reading

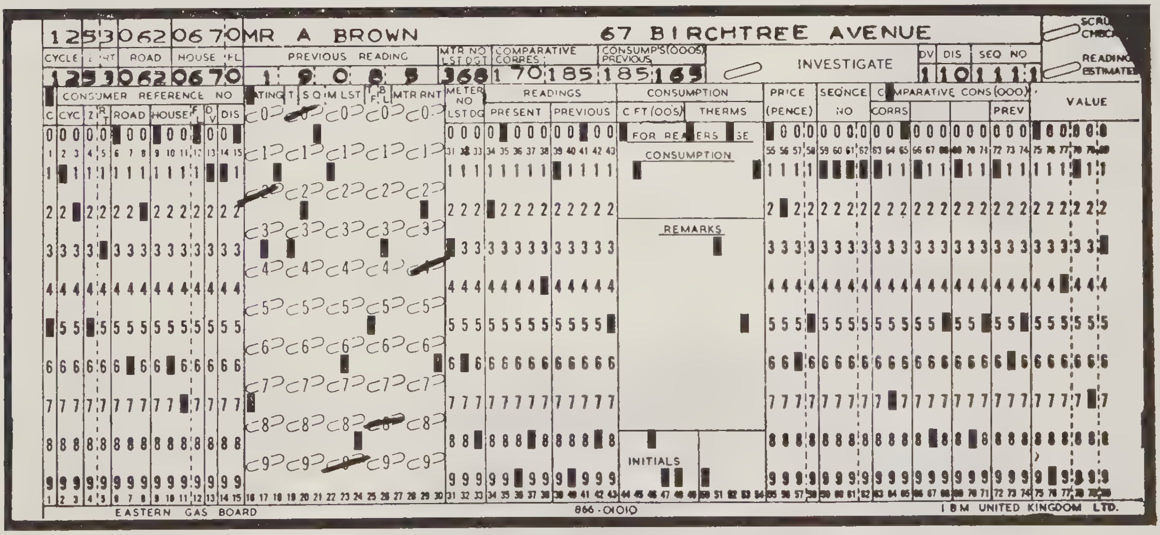
holes do not interfere with the operation of the machine. The marks on the card are sensed electrically. A group of three electrical contact brushes is passed down each column. The central brush of the group is connected to the positive side of an electrical circuit and the outside brushes to the negative side. The graphite deposited from the pencil being a conductor, when a mark is encountered by the brushes, a current will flow between the central brush and either one, or both, of the outer brushes. The electrical signal initiated in this way identifies the mark and sets the mechanical punch. Numbers read from the card are then punched into the same card in columns 34 to 38.

The machine can be arranged so that data sensed as marks in one area of the card can be punched into any other area. Cards are mark-sensed at the rate of 100 cards a minute.

Mark-sensing depends, of course, on the marks being made sufficiently bold for them to be detected with certainty in the mark-sensing machine. Initial experience has shown that once the meter readers become accustomed to recording readings in this way, badly marked cards fall to less than one per cent. When the scheme is in full operation, an average of 5,700 readings will be made each day.

The now-punched meter-reading cards are passed on to the IBM 604 electronic calculator and data are fed in and answers are received from it through an IBM 521 punching unit coupled to it. Cards are read at the rate of 100 a minute and the answers are punched into the same cards that contain the factors of the

Meter-reading card. The reading 20984 is marked in columns 16 to 30. When mark-sensed the same data are converted into holes punched in columns 34 to 38



1253062067 0 MR A BROWN 67 BIRCHTREE AVENUE

CYCLE | RT | ROAD | HOUSE | FL | PREVIOUS READING | MTR NO LST DGT | COMPARATIVE CORRES | CONSUMP'S (000S) PREVIOUS | INVESTIGATE | DV | DIS | SEQ NO

1253 062 0670 | 1 9 0 8 5 | 368 | 1 70 185 | 185 165 | 1 | 10 | 111

CONSUMER REFERENCE NO

C | CYC | Z | RT | ROAD | HOUSE | F | DV | DIS | RATING | T | S Q M LST | T B F L | MTR RNT | METER NO LST DG | READINGS PRESENT | PREVIOUS | CONSUMPTION C FT (00S) | THERMS | PRICE (PENCE) | SEQNCE NO | COMPARATIVE CONS (000) CORRS | PREV | VALUE

FOR READERS USE

CONSUMPTION

REMARKS

INITIALS

EASTERN GAS BOARD

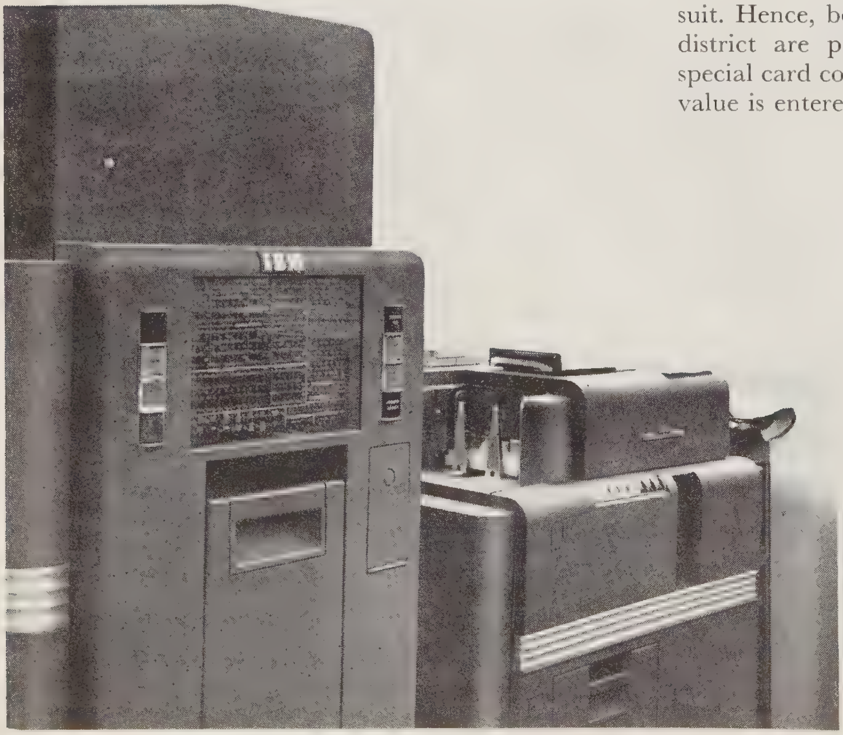
866-01010

I B M UNITED KINGDOM LTD.

Mark-sensing meter-reading cards in an IBM 519 *at a speed of* 100 *cards a minute*

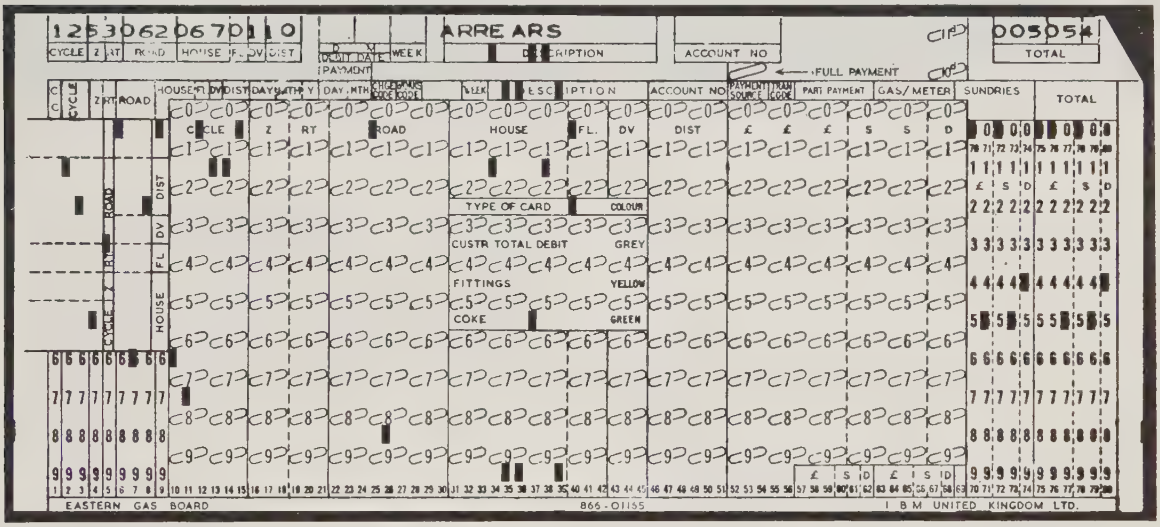
calculation. The action of the calculator is controlled by a wired panel on which up to 70 different programme steps can be set up. Control panels are changed, or rewired, every time the calculator is required to perform a different calculation. All the calculations necessary for converting the volume of gas consumed into a cost to be charged to the customer are done in one operation. The cards are fed into the IBM 521 connected to the calculator and the sequence of events is as follows:—First, the previous meter reading (columns 39-43) is subtracted from the present reading (34-38) and the answer, gas consumed measured in cubic feet, is punched into columns 44 to 49. Gas consumed is then multiplied by a factor representing the calorific value of one cubic foot of gas and the result in therms is punched in columns 50 to 54.

This calorific value factor will remain constant for all cards obtained from one district, but as the calorific value of gas supplied can vary from district to district the factor has to be altered to suit. Hence, before the cards from a particular district are passed through the calculator a special card containing the appropriate calorific value is entered. The calculator reads this card



Calculations of price to be charged for gas are performed on an IBM 604 *electronic calculator. On the right is the IBM* 521 *punch connected to the calculator. All input and output data for the calculator proceed through the punch* and stores the factor internally and applies it during the calculations on the batch of cards that follows. The computation ends with a calculation that assesses the amount to be charged, taking into account the particular tariff rate under which gas is being supplied to the customer. Value of gas supplied, recorded in £ s. d., is then punched in the final columns of the card (75-80).

It should be emphasized that the entire calculation sequence just described is performed in one operation and that all the answers required—gas consumed, thermal value and the cost—are punched in the card simultaneously.



Arrears cards are among the four types of charge cards collated with the meter-reading cards previous to printing the bill

The cards are then run through the calculator for a second time to check the accuracy of the calculations and punchings that were made during the first run, and also to punch a block number in column 26. This block number is required for various statistical and checking purposes.

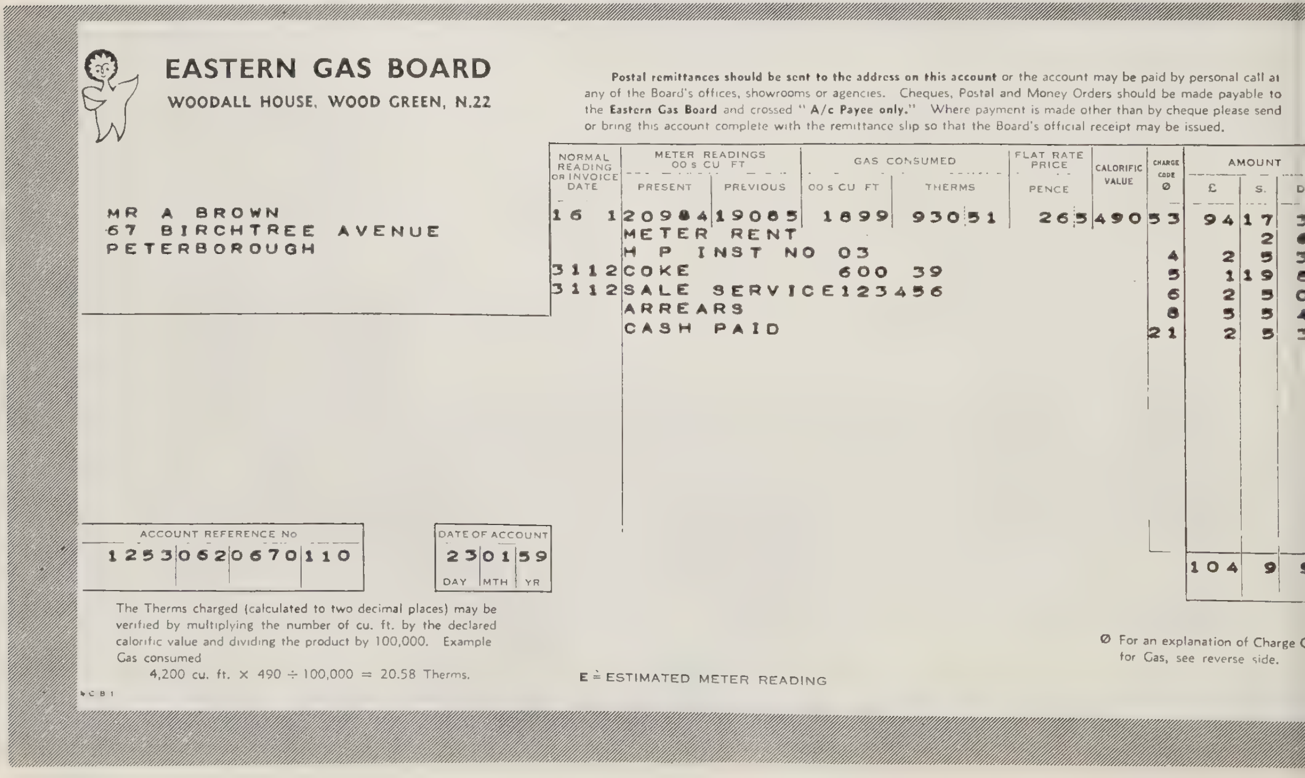
A stage has now been reached where all the various charges relating to each customer have to be collected together so that the complete bill can be prepared. It will be remembered that the remaining three services which customers might or might not use are fitting, hire-purchase and the supply of coke. Charges assessable under these headings are received at the central billing office as various printed and handwritten documents. The appropriate data are transcribed from these documents on to punched cards by girls who operate manually IBM 024 and IBM 056 card punching machines and verifiers. Verification, of course, is a similar operation to card punching and is done to confirm the accuracy of the transcription. Some charges, such as hire-purchase instalments, will remain the same from quarter to quarter and consequently once a card has been created for this charge the card can be automatically reproduced and carried forward from quarter to quarter. Manual transcription of data on to cards, therefore, only has to be done for new or non-recurring items.

The three groups of cards listing the amounts to be charged for coke, fitting and hire-purchase are sorted into account-number order, together with arrears cards brought forward from the previous quarter. All these sorted cards are next merged with the meter-reading cards by passing them through an IBM 077 collator. A collator will feed cards in sequence from two input hoppers to produce one complete pack of cards arranged in the correct order. In this the meter-reading cards recording gas consumed are

Bills are printed on continuous stationery by an IBM 441 machine. Two close-line-spaced carbon copies are also produced

interposed among the previously sorted cards so that all the cards relating to one account number are brought together. The collator works at a speed between 240 and 480 cards a minute. The complete pack of cards, now arranged in correct account-number order, is then taken to an IBM 441 accounting machine. This prints the bills to be sent to the customers. Two input hoppers are provided on the accounting machine. In one hopper are placed all the charge cards and in the other, cards from the customer name and address file. These latter cards are in the same order as the charge cards. Name and address information is read from the customer-address card and printed on the top left-hand corner of the bill, and the individual charges for the various services used are read from the sequence of charge cards related to that

Quarterly bill. When payment is made the remittance slip on the right is returned to the central billing office



EASTERN GAS BOARD
WOODALL HOUSE, WOOD GREEN, N.22

Postal remittances should be sent to the address on this account or the account may be paid by personal call at any of the Board's offices, showrooms or agencies. Cheques, Postal and Money Orders should be made payable to the **Eastern Gas Board** and crossed "**A/c Payee only.**" Where payment is made other than by cheque please send or bring this account complete with the remittance slip so that the Board's official receipt may be issued.

MR A BROWN
67 BIRCHTREE AVENUE
PETERBOROUGH

NORMAL READING OR INVOICE DATE	METER READINGS 00s CU FT		GAS CONSUMED		FLAT RATE PRICE	CALORIFIC VALUE	CHARGE CODE Ø	AMOUNT	
	PRESENT	PREVIOUS	00s CU FT	THERMS	PENCE			£	S.
16 1	20984	19065	1899	930 51	26 5	490	53	94	17
	METER RENT								2
	H P INST NO 03						4	2	5
3112	COKE		600	39			5	1	19
3112	SALE SERVICE123456						6	2	5
	ARREARS						8	5	5
	CASH PAID						21	2	5
								104	9

ACCOUNT REFERENCE No
1253 062 0670 110

DATE OF ACCOUNT		
23	01	59
DAY	MTH	YR

The Therms charged (calculated to two decimal places) may be verified by multiplying the number of cu. ft. by the declared calorific value and dividing the product by 100,000. Example Gas consumed

4,200 cu. ft. × 490 ÷ 100,000 = 20.58 Therms.

E ≐ ESTIMATED METER READING

Ø For an explanation of Charge C for Gas, see reverse side.

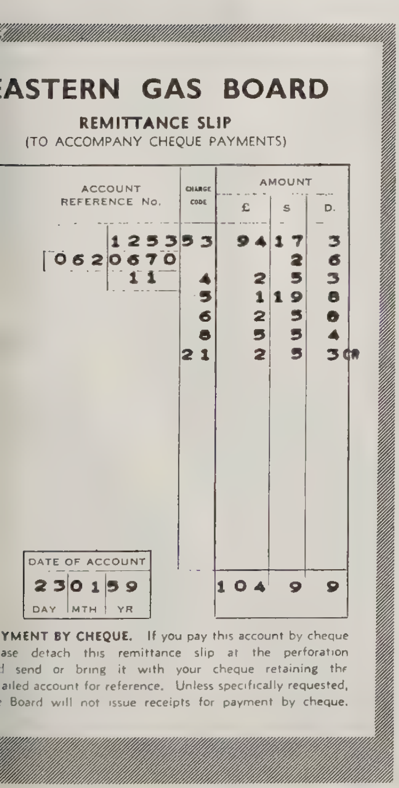
CB 1

account. Charges are listed underneath each other on individual lines and a total, automatically summed by an adding register in the accounting machine, is printed at the foot of the bill.

At the same time that the bill is printed, two close-line-spaced carbon copies of the document are made. Close-line spacing is achieved by feeding the two copy papers with their carbons at a lower speed than the top printed copy, the customer's bill.

A full printed description of each item is given on the bill in addition to the cost, so customers do not have any difficulty in understanding the bill. On the extreme right of the bill the data are repeated, less printed descriptions. This portion of the bill, the remittance slip, is torn off when payment is made and returned to the central billing office as a record that the money has been received.

An IBM 523 summary punch is connected to the accounting machine during the bill-printing operation and the amount due for payment is punched into a card called a total arrears card. One card is punched for each customer. These total arrears cards are held on file. As payments are made, the remittance slips will be returned to the central billing office and the arrears cards corresponding to the slips are removed from the file. Where only partial payments have been made, the amount paid is recorded on the cards by pencil marks. The cards are then mark-sensed and punched and fed through the IBM 441 accounting machine so that payment lists can be compiled and agreed with banking returns from the collecting offices. A summary punch connected to the accounting machine punches a balance card giving the net amount still owing and these cards become the new total arrears cards that will be carried forward to the next quarter's billing operation if no further payment is made.



EASTERN GAS BOARD

REMITTANCE SLIP

(TO ACCOMPANY CHEQUE PAYMENTS)

ACCOUNT REFERENCE No.	CHARGE CODE	AMOUNT £	s	D.
12533	53	94	17	3
062 0670			2	6
11	4	2	5	3
	5	1	19	8
	6	2	5	0
	8	5	5	4
	21	2	5	3CR
		104	9	9

DATE OF ACCOUNT

DAY	MTH	YR
23	01	59

YMENT BY CHEQUE. If you pay this account by cheque ase detach this remittance slip at the perforation d send or bring it with your cheque retaining the ailed account for reference. Unless specifically requested, Board will not issue receipts for payment by cheque.

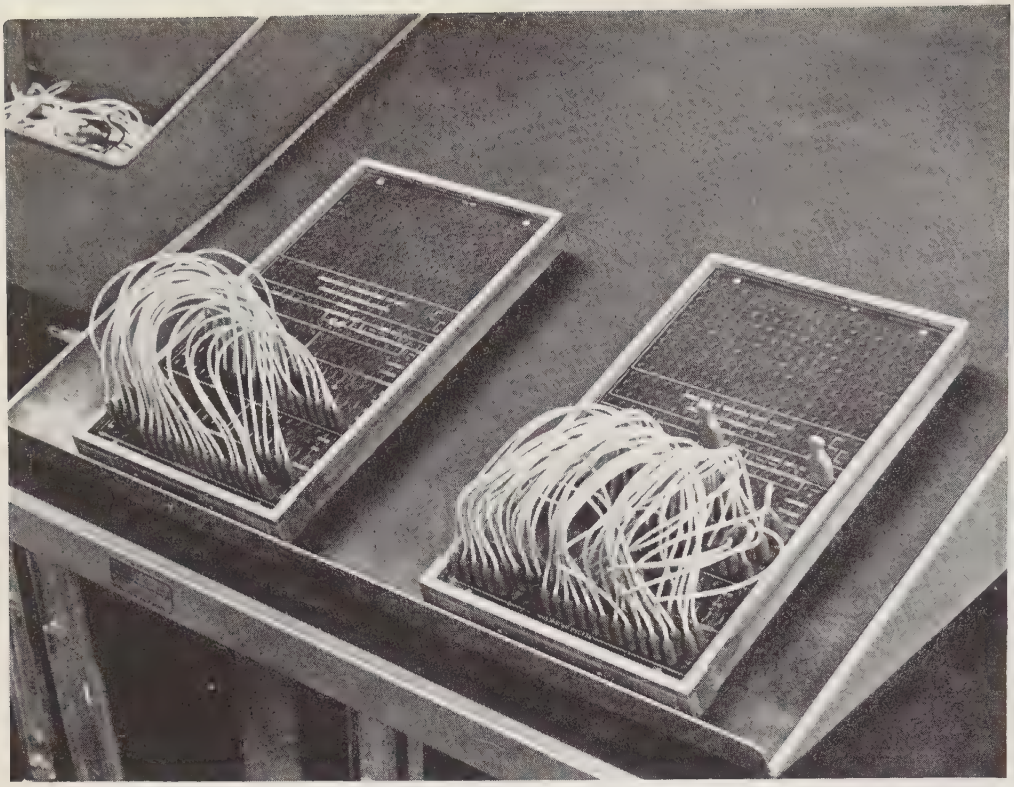
All the original charge cards, after they have been used to produce the bills, are segregated into their respective service groups—coke, fitting, hire-purchase and so on—and are then used in other data processing procedures to produce significant statistics for the Ministry of Power, the Gas Council and the Area Board itself.

Preparing new meter-reading cards

One more important operation has to be performed with the meter-reading cards. New meter-reading cards will, of course, be required for the next quarter and these are automatically reproduced from the present cards. The IBM 519 machine is used for this work as well as for mark-sensing. Much of the data recorded on the present card, although needed on the new card, must be repositioned. For instance, the present meter reading has to be reproduced in the card for the next quarter as the previous meter reading. Also, the consumption figures for previous quarters have all to be moved forward one quarter to keep them in the correct corresponding positions. All this is done automatically once the panels that control the operation of the machine have been correctly wired up.

The data reproduced are entered as punched holes in the new cards. The same data are printed along the top of the cards by passing them through an IBM 552 interpreter. This interpreter reads data as holes punched in a card and prints this information on to the same card in the required positions entirely automatically. The interpreter operates at a speed of 60 cards a minute.

At the conclusion of this operation all the meter-reading cards needed for the next quarter will have been prepared; they are then stored in the regional offices until required for issue to the meter readers when the next calls are due to be made. Not all the customers who are supplied with gas by the Eastern Gas Board are credit customers. The number is approximately 330,000.



Wired panels, which can be easily changed, control the operation of the machines

Fitting a control panel to an IBM 552 interpreter that prints the data on cards

The remaining 420,000 customers use coin meters, so no gas charges have to be computed for these. However, both types of customer use the other services for which quarterly bills have to be prepared.

Of course, the description just given does not cover all aspects of the work embraced by the central billing office. Among these is an interesting method of feeding data about new customers into the general system using Creed teleprinters and an IBM 143 punched tape to card converter. Also, final notices are prepared using the cards in the total arrears file in conjunction with the name and address file.

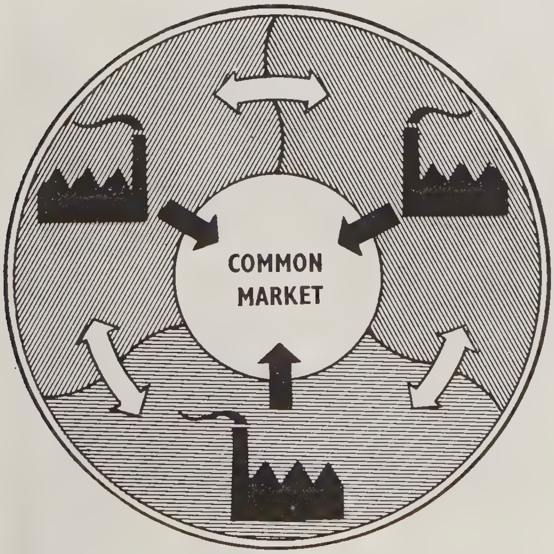
The system is comprehensive and performs all the necessary clerical work required to maintain control over billing. Perhaps the most revolutionary innovation, certainly as far as a public utility is concerned, is the adoption of mark-sensing to record meter readings. Indeed, it is thought that the Eastern Gas Board are the first people to use mark-sensing for this purpose in Great Britain. The virtue, of course, is that it eliminates manual transcription of data and thus conforms with that unwritten law of data processing—"All significant data should be captured at source."

Training future executives

Many have heard or read about the electronic computer-based exercise called "The Management Decision Game". They know that its object is to assist in preparing junior and middle management for the responsibilities that one day it will have to carry. But what, in all probability, top management does not know for certain is whether the game is of any real value and, if it is, where it can be played, the time involved and what the cost is.

This article not only enables individual managements to assess the value of the new method of training, but also answers all the other salient questions.

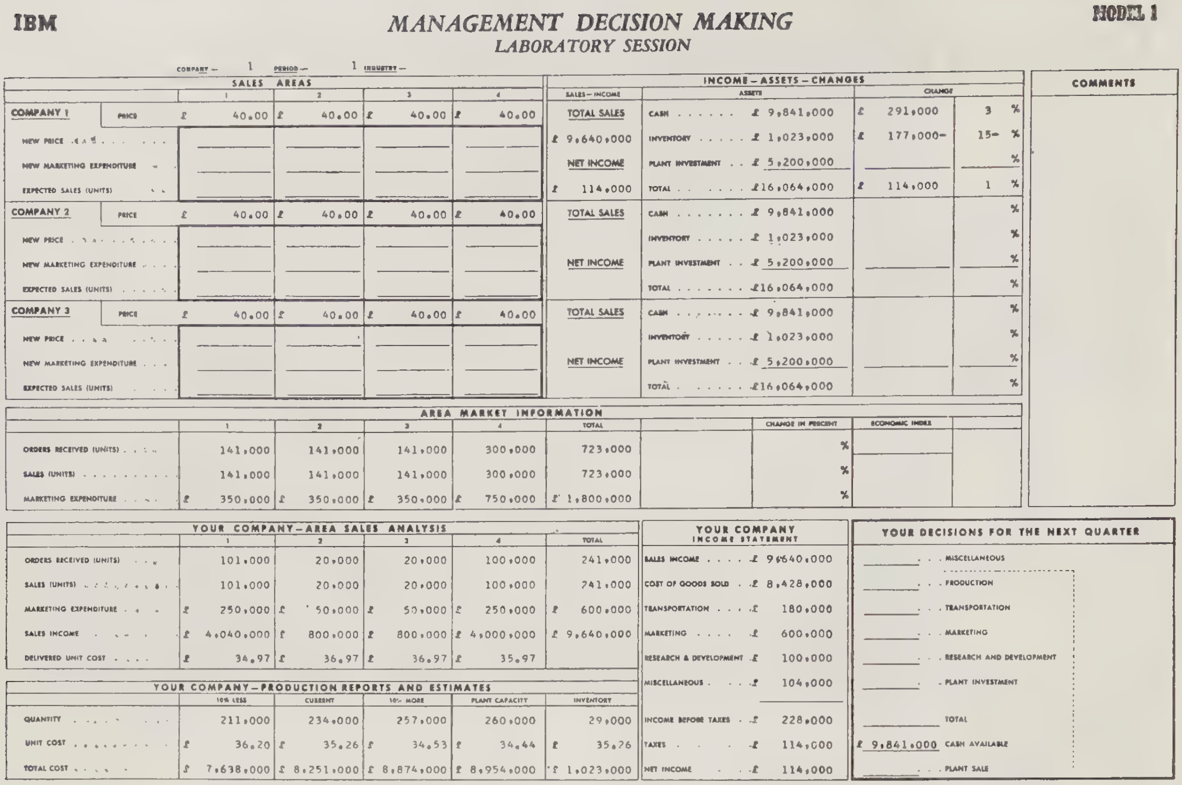
If work that seems dull could be made an intriguing, competitive game—a game that could be played . . . . Often management has thought on these lines, and obviously it is the lines on which the originators of the Management Decision Game were thinking when they developed the training aid recently introduced into Great Britain by IBM United Kingdom, Ltd. One day more sophisticated versions of the game may be developed. In the United States they are seeking to simulate true economic conditions, albeit crudely, but with sufficient accuracy for future general economic trends, and their effect, to be determined. This may be achieved eventually. However, for training purposes there is already something tangible in the basic notion that a mathematical relationship exists between the various economic factors controlling the pattern of trade.



Three teams, representing the Boards of three firms, play the game. Each firm sells products in its own home market, a common market and also in the home markets of its two rivals

In the game that has been devised there are three teams acting as the Boards of three separate companies, each manufacturing and marketing a similar product. None of the companies is in good heart—which is probably wise from the psychological angle. A typical starting condition is the end of a financial year in which there was a net income of £114,000 on a capital investment of £16,064,000. Other criteria at the time of the "take-over" are that all three companies are selling their products at a price per unit of £40 and that there are four markets open to each company. Three of these four markets are the home areas in which the individual firms are situated. Hence each firm has an area in which it has an advantage over its competitors and two areas in which one or other of its rivals is at an advantage. The fourth area constitutes a "common" market.

Each Board is given information on the total sales achieved in each area including expenditure on marketing. In addition to this general market information each company has a report revealing its own sales position, plant capacity, total production cost, cost per unit and the



IBM *MANAGEMENT DECISION MAKING* **MODEL 1**

LABORATORY SESSION

COMPANY — 1 PERIOD — 1 INDUSTRY —

SALES AREAS		1	2	3	4
COMPANY 1	PRICE	£ 40.00	£ 40.00	£ 40.00	£ 40.00
NEW PRICE					
NEW MARKETING EXPENDITURE					
EXPECTED SALES (UNITS)					
COMPANY 2	PRICE	£ 40.00	£ 40.00	£ 40.00	£ 40.00
NEW PRICE					
NEW MARKETING EXPENDITURE					
EXPECTED SALES (UNITS)					
COMPANY 3	PRICE	£ 40.00	£ 40.00	£ 40.00	£ 40.00
NEW PRICE					
NEW MARKETING EXPENDITURE					
EXPECTED SALES (UNITS)					

INCOME — ASSETS — CHANGES

SALES — INCOME	ASSETS		CHANGE	
TOTAL SALES	CASH	£ 9,841,000	£ 291,000	3 %
£ 9,640,000	INVENTORY	£ 1,023,000	£ 177,000-	15- %
NET INCOME	PLANT INVESTMENT	£ 5,200,000		%
£ 114,000	TOTAL	£16,064,000	£ 114,000	1 %
TOTAL SALES	CASH	£ 9,841,000		%
	INVENTORY	£ 1,023,000		%
NET INCOME	PLANT INVESTMENT	£ 5,200,000		%
	TOTAL	£16,064,000		%
TOTAL SALES	CASH	£ 9,841,000		%
	INVENTORY	£ 1,023,000		%
NET INCOME	PLANT INVESTMENT	£ 5,200,000		%
	TOTAL	£16,064,000		%

COMMENTS

AREA MARKET INFORMATION

	1	2	3	4	TOTAL		CHANGE IN PERCENT	ECONOMIC INDEX	
ORDERS RECEIVED (UNITS)	141,000	141,000	141,000	300,000	723,000		%		
SALES (UNITS)	141,000	141,000	141,000	300,000	723,000		%		
MARKETING EXPENDITURE	£ 350,000	£ 350,000	£ 350,000	£ 750,000	£ 1,800,000		%		

YOUR COMPANY—AREA SALES ANALYSIS

	1	2	3	4	TOTAL
ORDERS RECEIVED (UNITS)	101,000	20,000	20,000	100,000	241,000
SALES (UNITS)	101,000	20,000	20,000	100,000	241,000
MARKETING EXPENDITURE	£ 250,000	£ 50,000	£ 50,000	£ 250,000	£ 600,000
SALES INCOME	£ 4,040,000	£ 800,000	£ 800,000	£ 4,000,000	£ 9,640,000
DELIVERED UNIT COST	£ 34.97	£ 36.97	£ 36.97	£ 35.97	

YOUR COMPANY—PRODUCTION REPORTS AND ESTIMATES

	10% LESS	CURRENT	10% MORE	PLANT CAPACITY	INVENTORY
QUANTITY	211,000	234,000	257,000	260,000	29,000
UNIT COST	£ 36.20	£ 35.26	£ 34.53	£ 34.44	£ 35.26
TOTAL COST	£ 7,638,000	£ 8,251,000	£ 8,874,000	£ 8,954,000	£ 1,023,000

YOUR COMPANY
INCOME STATEMENT

SALES INCOME	£ 9,640,000
COST OF GOODS SOLD	£ 8,428,000
TRANSPORTATION	£ 180,000
MARKETING	£ 600,000
RESEARCH & DEVELOPMENT	£ 100,000
MISCELLANEOUS	£ 104,000
INCOME BEFORE TAXES	£ 228,000
TAXES	£ 114,000
NET INCOME	£ 114,000

YOUR DECISIONS FOR THE NEXT QUARTER

	MISCELLANEOUS
	PRODUCTION
	TRANSPORTATION
	MARKETING
	RESEARCH AND DEVELOPMENT
	PLANT INVESTMENT
	TOTAL
£ 9,841,000	CASH AVAILABLE
	PLANT SALE

All the basic commercial data given to a team, representing one of the company Boards, are printed on this form. The conditions existing at the start of the game are shown. Decisions for the next quarter are recorded in the panel in the lower right corner

delivery costs in each of the four markets. The total cash available to each is £9,841,000, and what the teams have to do is to allocate their resources in what they conceive to be the best possible way—do this relative to the four markets and five other variables, viz., plant investment, production, research and development, transportation and marketing.

The number of members in a team can be three to eight. Five is probably the ideal figure. Too large a team obviously reduces the sense of personal participation.

Each team, of course, reaches its decisions independently. But in spite of having access to an electronic computer—this being a game and there being need to compress—the teams have to make decisions that are immutable for three months. At the end of each period of the game, representing three months, the teams know from the computer the results their particular company has achieved and can adjust their policy in light of the experience gained. At the end of four such periods there is the annual balance sheet of each company—available for all to see.

The game covers a total period of three years. Access to a computer is necessary and, in particular, an IBM 650 computer, since the programme has been written for this machine. In the main, the programme comprises a series of mathematical equations linking all the various factors, but there are, of course, data relating to the market potential and various basic assumptions, as, for example, the more money spent on research the lower, ultimately, the cost of the product, and the more expended on market promotion the larger the volume of sales.

After the teams have decided how to allocate their resources and fixed their new selling prices, the whole of the data is punched into cards and entered into the computer.

For the first policy decisions, those to cover the first three months' trading, the teams are allowed 1½ to 2 hours. Thereafter the amount of time is reduced to 20 minutes. Hence with the game covering three years—12 three-month trading periods—the total time occupied is roughly 5½ hours, plus 10 to 15 minutes per session for processing the data on the computer. Of course, what the game cannot teach is that it is thoroughly bad to keep chopping and changing budget allocations. Research and development, for example, cannot be built up in a trice, even though it can be axed overnight; and there is that far from minor matter, the human problems of the personnel employed.

Invariably it is found that during the first year's trading operations the participants learn —usually the "hard" way—some of the more important commercial aspects, not least the necessity to sell units for more than they cost to produce, this instead of merely seeking to do the rival companies down. In the second year's operations, competence in determining the best way to use the available capital is usually achieved. In the third and final year, most of the lessons the game is capable of teaching have been learnt and, as a rule, all three companies are found to be making a reasonable profit.

Should the players become too adept, whoever is in charge merely alters one or two details of the programme in the computer. Maybe he will reduce the size of the available market, quarter by quarter, thus representing a slow, insidious slump. Alternatively, he may alter the conditions in one particular "home" market so that it is more difficult for the other two firms to sell in it. It is easy, therefore, to make the game more difficult or less difficult to accord with the aptitude of the teams.

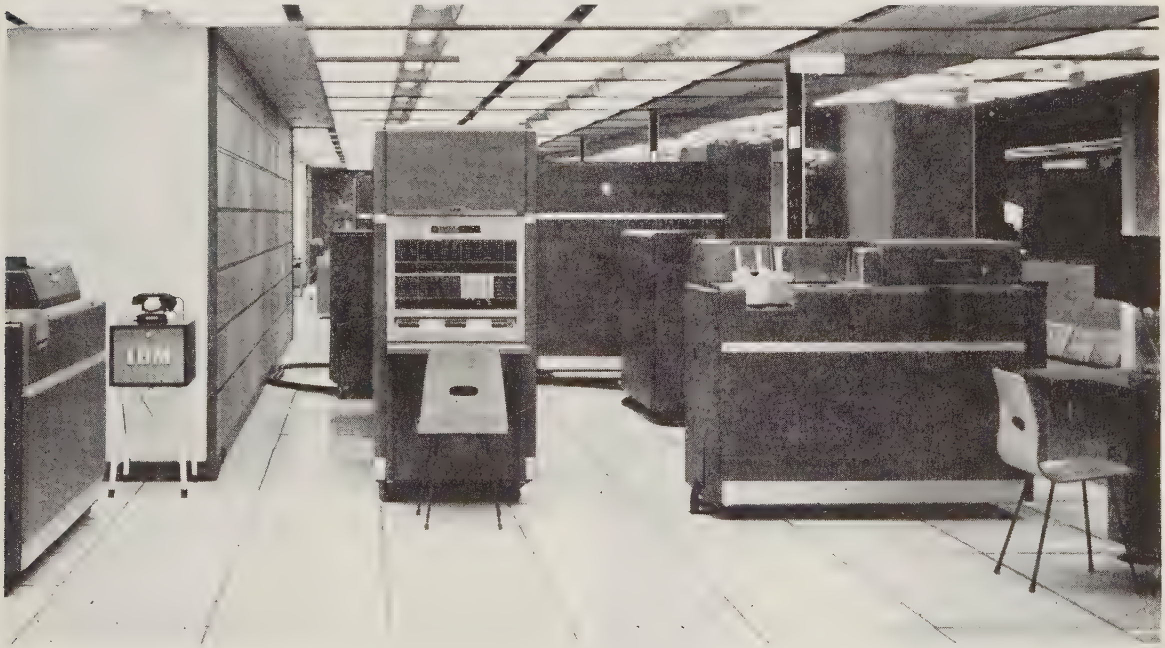
Of course, in spite of its realism, it is a game and there is no suggestion that the technique in its present form should be used in connection with actual commercial decisions. Perhaps the greatest advantage is that the results are presented so soon after the decisions are made that all the relevant facts are still closely in mind. Further, each team is always well aware of its direct responsibility for the results, good or bad.

Cost

Earlier, the question of computer time was mentioned. This is approximately three hours. The current cost of hiring an IBM 650 is about £36 an hour, so if 15 people play the game the cost per person works out at about £7.

No doubt most firms wishing to make use of this training method will contact a computer service. Although IBM do not intend to enter the management training field, they are arranging to run sessions at their London data processing centre for the development of their own staff and also for other companies who are interested.

Data for the Management Decision Game can be processed on an IBM 650 *computer such as this one situated at the London office of IBM. The game is used by IBM to train their own staff*



Punched feature cards

A simple, inexpensive system of processing data without resort to any mechanical aid other than a card punch

In a feature card system every card has from 1,000 to 10,000 numbered positions, each denoting an item. The card itself represents one feature, characteristic, quality or attribute of an article or individual. If an item does in fact possess the feature, that item's position on the card is punched. Stacking the cards relating to a particular subject enables the operator to determine at a glance whether the hole punched in a given position mates with holes in the other cards—whether, for example, the man to whom hole No. 1156 on the "engineers" card relates is an electronic engineer and therefore should be considered as a possibility for some new work that is about to be undertaken. If the holes on the cards headed "engineers" and "electronics" do mate, obviously he is one of those for consideration and his file, No. 1156, is examined for further information.

With the feature card technique it is possible to select and compare items, and sets of items, of all types at great speed. The article that follows gives an insight into the methods and also provides detailed information about a system that has now been in operation for more than a year.

By J. L. Jolley, M.A., B.Sc. (Econ.)

Use of punched cards is not confined solely to mechanical data processing systems. Many designs of punched card exist and several of the systems are operated manually with the simplest of equipment. One such system is based on the use of feature cards. The distinguishing mark of a feature card is that it represents a particular feature, characteristic, quality or attribute of the item recorded, instead of detailing the item itself.

Many thousands of items can be represented on one feature card, by holes punched through numbered positions. A typical feature card is ruled so that there is a lattice of small squares printed on the face. A number is printed in each square and this number provides the identification by which the item to which it refers can be located. A small card measuring 6 inches by 11 inches may provide 1,000 numbered positions while 10,000 numbered positions can be arranged, without overcrowding, on a card that measures 10 inches by 12 inches.

Thinking in terms of features is not always easy at first, so this point will be clarified. A convenient way of distinguishing between a feature card system and the more conventional item card system is to think of a set of 1,000 things. Each of these may have none, any or all of 100 characteristics or features. To record this set of things an item card system would have 1,000 cards, whereas a feature card system would use 100.

To take a simple case, if a feature card system was used solely for personnel records and a new employee, Mr. John Smith, joined the firm in the capacity of electronic engineer, a file would be created to contain all the documents relating to Mr. J. Smith and this file would be given a reference number. The number chosen would be one of the unallocated numbers appearing on the feature card, say, 1156. The

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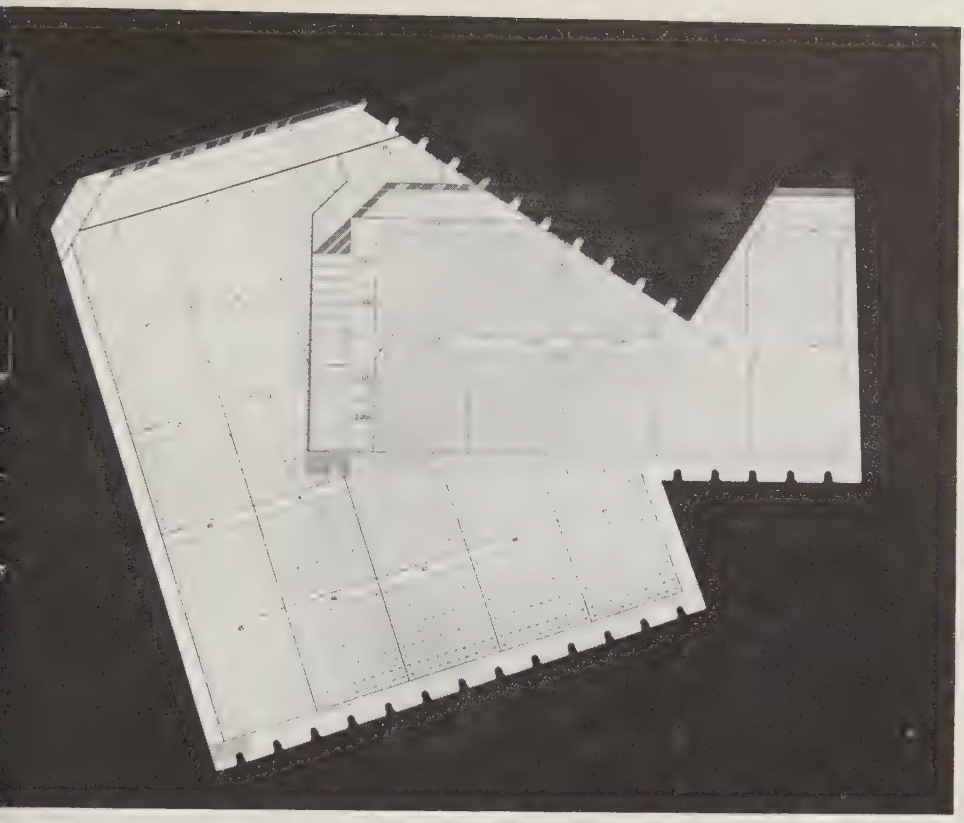
Mr. J. L. Jolley is Managing Director of J. L. Jolley & Partners, Ltd.



Feature cards. The large card has 2,500 numbered positions and the small card 1,000. Transparent coloured sheets, as shown at the top, are placed behind the cards to emphasize the positions of the punched holes. The cards are reproduced approximately quarter size

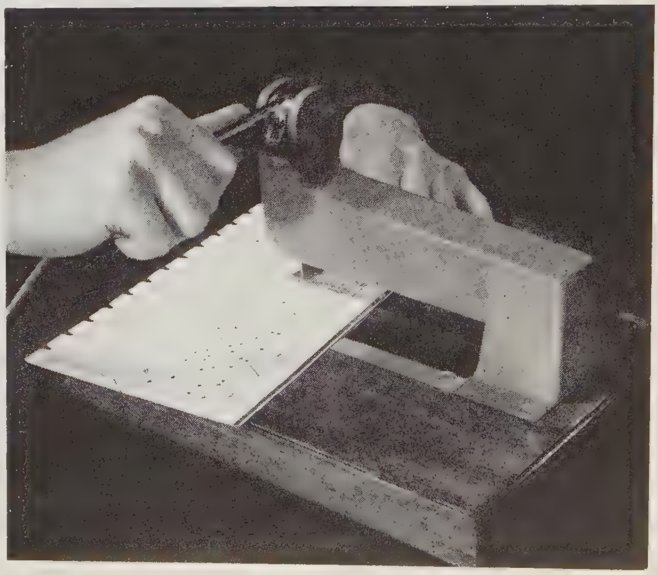
file of feature cards concerned with personnel records would contain a card bearing the title "engineers." A hole would be punched through the card in the position of the square numbered 1156.

Another feature card in the system would be entitled "electronics" and a hole would again be punched through the square 1156. These cards would, of course, contain many other punched holes. All the holes in the "engineers" card would refer to files of all the engineers employed by the company, whether electronic, mechanical or otherwise. Similarly all holes in the "electronics" card refer to all employees having this word in the description of their job. If the "electronics" and the "engineers" cards are stacked one upon the other, through-going holes will appear in positions referring to all employees who possess both features. One of these through-going holes will, of course, appear in the position 1156—the number of the file containing details of Mr. John Smith.

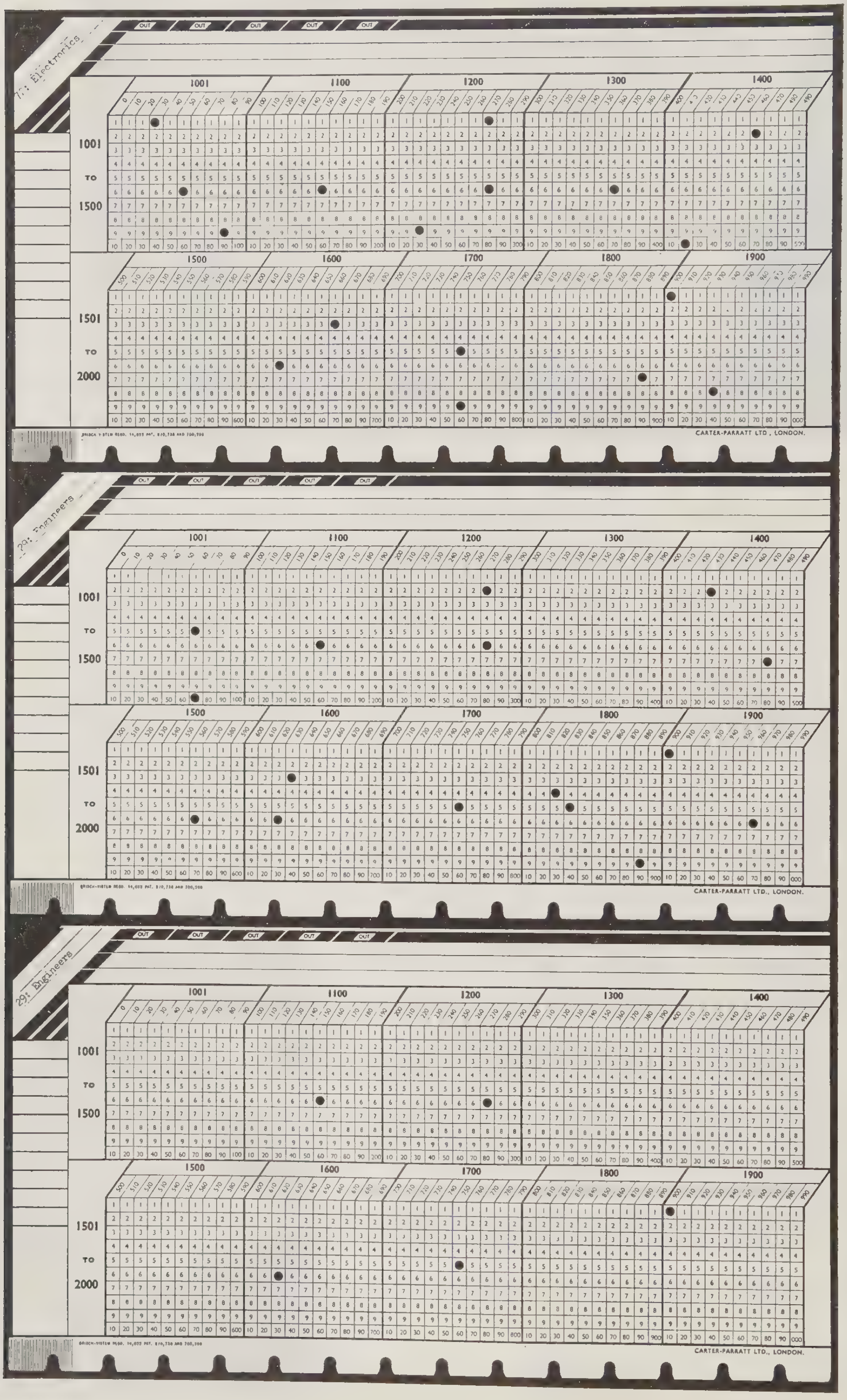
In a feature card system any number of characteristics can be accommodated and an item possessing twenty characteristics is punched in twenty cards, a hole appearing in the same numbered position in each of the twenty cards. Since all other items recorded on these cards that have the same set of twenty characteristics will also be identified by through-going holes, the stacking of feature cards is a rapid means of finding, from among large numbers of items, every one which will satisfy a particular set of requirements.

To discover, from a record of industrial accidents, those which occurred in the assembly shop on the night shift owing to mechanical failure, all that is necessary is to stack the three relevant feature cards concerned with accidents entitled "assembly shop," "night shift," and "mechanical failure." Through-going holes

Holes are made in the cards with this simple manually operated portable punch unit



To locate a particular item, cards describing its features are stacked together and through-going holes indicate all items that fulfil the requirements. In this particular example the top-card shows all personnel who have "electronics" in their title, the second card all personnel described as "engineers." When these two cards are placed together (as in the bottom illustration) all personnel who are "electronic engineers" will be indicated by through-going holes

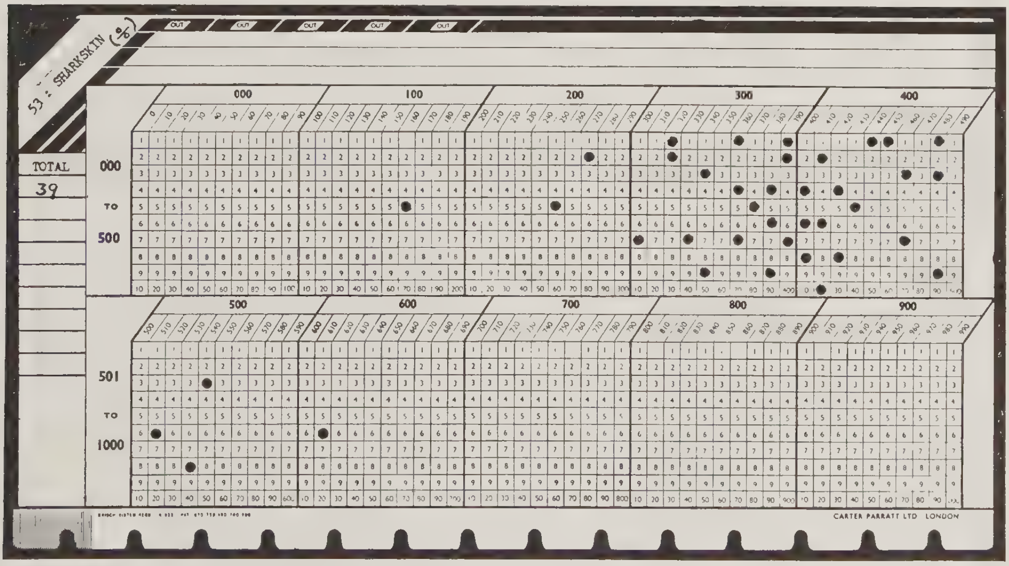


Feature cards can be selected easily from specially designed filing racks

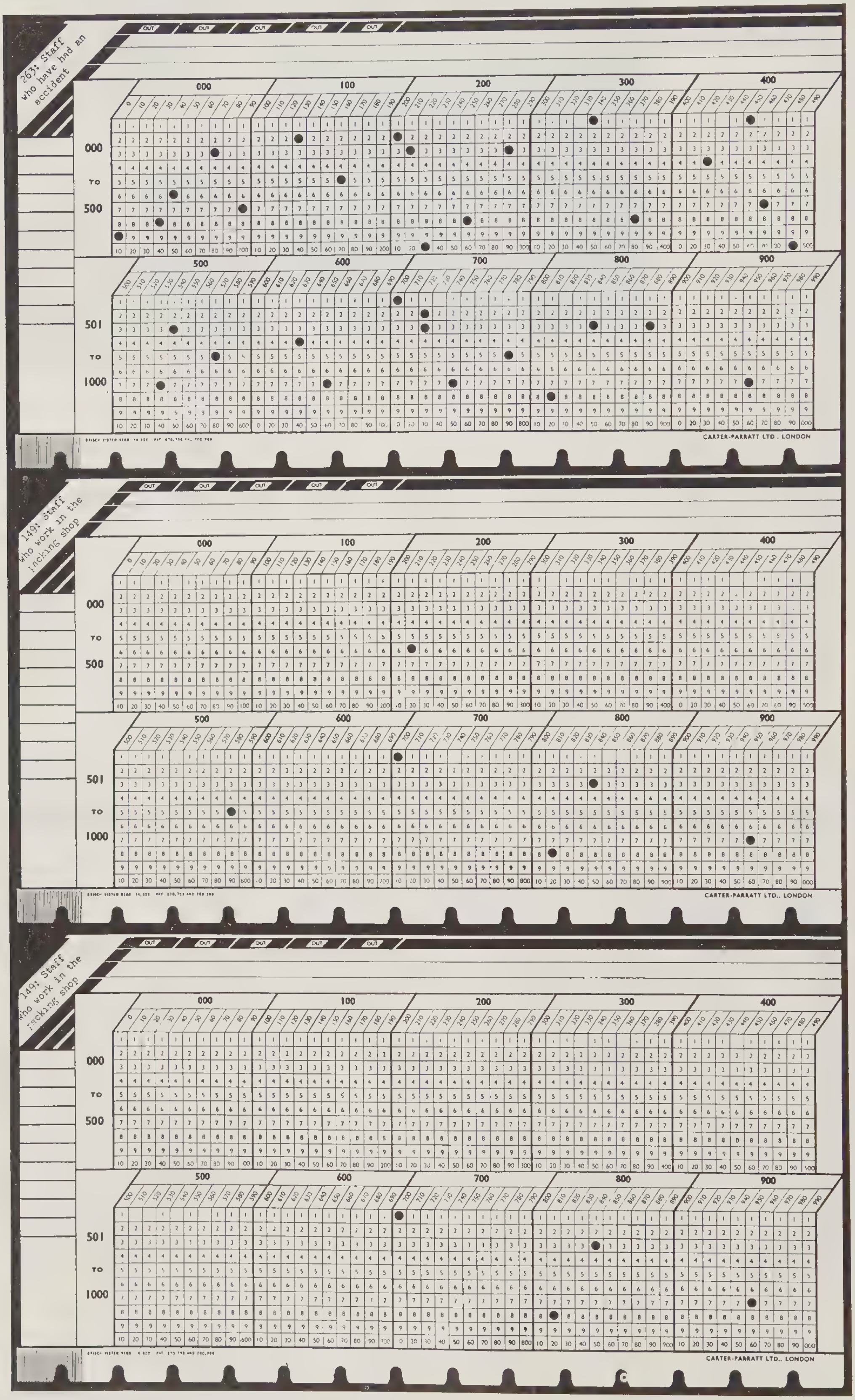
then show how many such accidents there were, and what reference numbers they were given. Thus a second comparison with an item card system is possible, on the basis of the number of card handlings. In a feature card system recording, for example, a thousand accidents spread over the years, the discovery of all accidents possessing three given characteristics involves, as shown above, the handling of three cards only. In an item card system, with one card per accident, at least a thousand cards must be handled. If selection cannot be made of three characteristics simultaneously from amongst the thousand cards, but instead the cards have to be examined for one characteristic at a time, card handlings may easily reach twice this figure.

Since it is possible to put items into special sequences (for example, into the order in which they come to hand or occur) the position of the holes punched in feature cards can be visually meaningful. In the accident record example a

Patterns made by punched holes can be full of meaning. From this card, on which are recorded the sales of the textile sharkskin, it is apparent that demand is not uniform through the year but is concentrated in one period



Feature cards can be used for research. The top card shows all employees in the factory who have had accidents. Next is the card showing the personnel employed in the packing shop. In the bottom illustration these two cards have been superimposed to reveal packing shop personnel who have had accidents. It also indicates that the accident rate is highest among the most recent recruits to this department


263: Staff who have had an accident
149: Staff who work in the packing shop
149: Staff who work in the packing shop
OUT
000 TO 500
501 TO 1000
CARTER-PARRATT LTD., LONDON

cluster of holes in, say, the top right-hand corner could indicate that accidents of a particular type all tended to occur at a particular period of the month or year: the period during which the top right-hand corner was being filled in.

Feature card systems also possess another great advantage, that of thinking for their employer. An example of this may be taken from the field of research. The quickest way of entering details of one item into a feature card system is to stack the cards that describe its features and then to punch a hole through the stack in the position dictated by the item's reference number. Thus, if the item concerned is part of a meaningful pattern, this pattern is revealed by the very act of stacking the cards for punching and without being purposely sought by the operator.

Control by feature cards

A special case of this arises when the items represent sales, accidents, quality-control test results, or other things which are constantly occurring and which require continuous surveillance. The mere entering of the details of a casualty, for instance, reveals all similar casualties, and the occurrence of more of these than would be expected in a given period indicates that there is a set of circumstances that is more than usually productive of disasters. Thus the very act of recording new accidents can trigger preventive action.

Another example of cards thinking for their user arises in record-keeping. Traditional methods rely very largely on indexing, so that, for instance, nuts and bolts and rivets and screws appear somewhere under the heading "mechanical engineering," while solder, fluxes and welding materials are probably under "metallurgy" and glues are under "animal and vegetable products" or "plastics and synthetic resins." Someone wanting to join two pieces of metal together would first decide the way he wished to do it and then seek the details in the relevant part of the index.

On the other hand, an inquirer using feature cards would put together the cards for "metals" and "fixing," "fastening," and "adhesion"; these would automatically reveal all items likely to satisfy his requirements. They would, of course, include solder, screws and glues, but they would also include magnets and the use of magnetism might, in fact, be the answer to his problem.

Feature card systems are of three main types: record keeping systems, in which the main object is to find which items out of large numbers of items exactly satisfy the user's requirements; research systems, in which the relationship of specific characteristics to each other is required; and control systems, in which the prime object is to receive a warning when something is not as it should be. The normal feature card system permits each of these three activities to be carried on at the same time, since the difference is largely one of how the system is used rather than arrangement.

Selecting Personnel

Thus a personnel officer who has indexed his company's employees on feature cards as a means of selecting suitable people for available jobs can, at any time if he wishes, use the index as a research vehicle to find how accident proneness is related to age or to the taking of or the failure to take the training scheme. Equally, he can use it as an aid to control: for instance, he can note the distribution of the age groups and thus take steps to control recruitment to obviate future "bulges" in particular departments or long periods of waiting for dead men's shoes.

To complete this general account of feature card systems in practice, it may be useful to study a particular case from its inception. The one chosen is a record of the external relationships a company has with those with whom it trades. There are three parts involved in the system: letters, papers, books and the like—collectively known as the files—the cards on which day-to-day developments are noted—which go by the name of the abstracts—and the feature cards themselves.

Abstracts and feature cards

The abstracts and feature cards comprise the basic working unit and are kept together in the same tray. They provide a summary of the contents of the files together with additional information such as notes of telephone calls. They bear the same reference numbers as the files. The files are numbered according to the numbers available on the feature cards.

Governing the whole system is a classified feature list which sets out the meanings of the cards. The making of this list was the first and most important operation in setting up the system. In choosing and arranging the meanings lies the basic skill involved in the creation of a feature card system. Among a number of other things, the final choice decides:—

Size of the System. A poor choice of features can result in many more cards being used than are needed for the purpose in hand; and more cards mean more and larger equipment and additional labour in manipulation, and therefore extra cost.

Flexibility of the System. A poor choice can also lead to much less information being obtainable. This is particularly the case in control and research applications.

Degree of Resolution of the System. Clearly if it takes ten cards to find an item when the superimposition of five would do as well, the system is not as efficient as it might be.

Accuracy of the System. A wrong choice of features can produce "ghost items," that is unwanted extras which appear in addition to those which fulfil requirements. Discarding these extras wastes time and can be avoided.

Mode of Growth of the System. The arrangement of the features chosen can affect the ease with which new features can be added if required, as well as the way in which this must be done. Poor arrangement can also lead to a neat system becoming unwieldy.

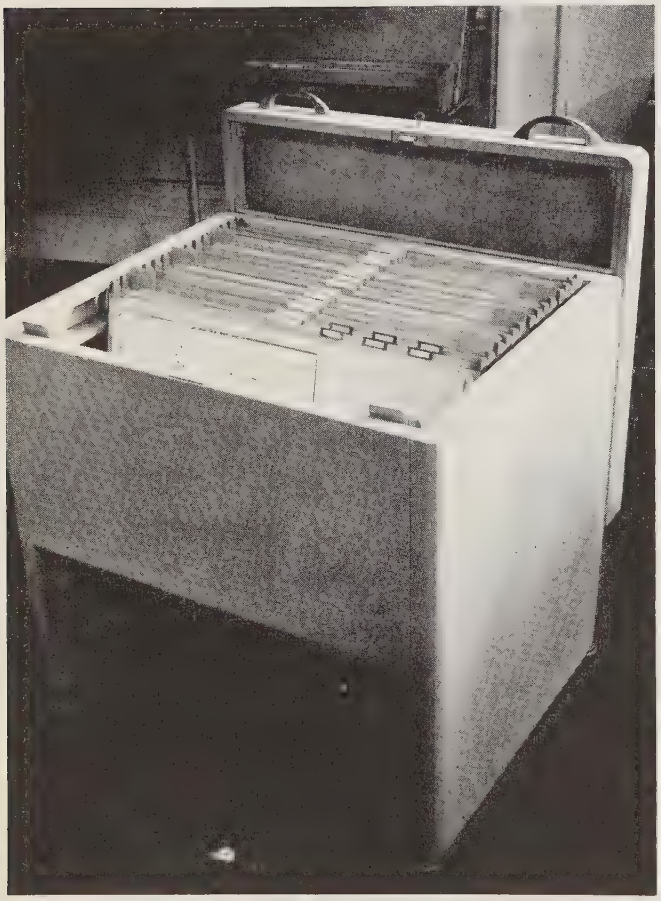
Ease of Use of the System. Systems that rate equally in all other respects can be easy, or hard, to use according to the features chosen. One set of meanings for the cards, for instance, may result in the order of stacking being important; another may make it immaterial.

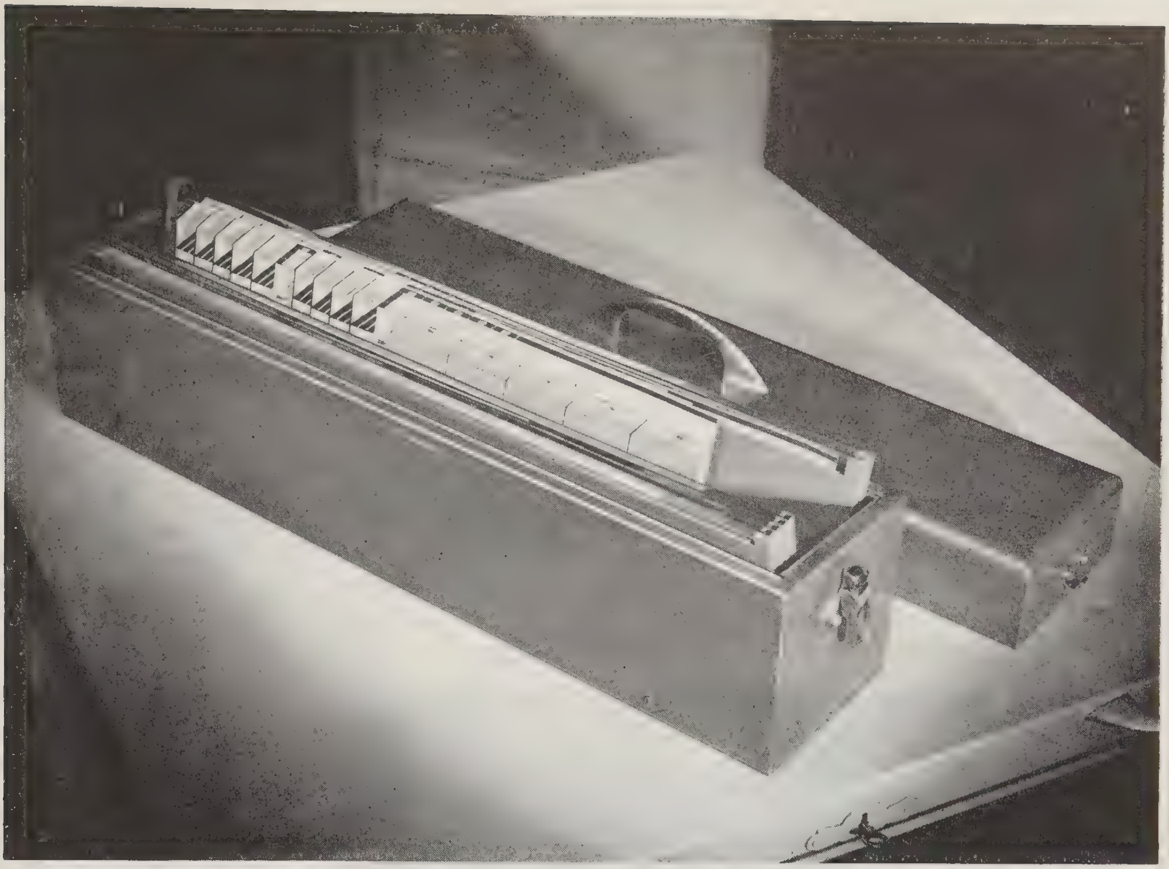
In the system being described, these and other matters were taken into consideration, and the result was a list of some two hundred meanings or features, each numbered and arranged under its relevant heading and marked in such a way as to show the user its appropriate method of use. These features were written, with their code numbers, on the top left-hand corners of feature cards ranged in rows leaning against movable flaps in a tray. Each row consists of 18 cards, overlapping sideways so that the titles of each can be seen and kept in an order dictated by their code numbers. Moving a flap forward reveals another row of cards leaning against the flap behind. This method of keeping the cards makes the selection of any given set of cards very easy.

When the feature cards were titled and arranged in their tray, all the files to which they were indexed were numbered, starting at 1 and proceeding upwards through the tens and the hundreds. For each file an abstract card was made. In many applications of feature cards such abstracts are unnecessary. In the case, for example, of a set of personnel records, if extra details are wanted, reference can be made directly from the cards to the employees' files. However, in this particular application the abstracts were also to be working documents in constant use. Consequently, details of the files were written on the relevant abstract cards, and these were then ranged, in number order, in the front of the tray containing the feature cards. The system was then ready for use.

A typical day's work with the system starts with the arrival of the morning's batch of letters. These are opened and their contents noted on the relevant abstract cards. If they alter anything—for instance, if the placing of an order is confirmed—this fact is noted by punching a hole in the appropriate item position on

Specially designed filing cabinet for storing large feature cards





Portable filing rack containing the smaller feature cards

the feature card bearing the title "order placed." The letters are then forwarded for answering; and copies of the answers are indexed on the abstracts and the feature cards in the same way. Similarly, if a telephone call comes in, its purport may be entered on an abstract card, and so may much additional incidental detail be gained from other sources.

To find all the available information on, for instance, patents, the feature card on that subject can be consulted. Holes in it denote items of many types: files containing articles, leaflets, or cuttings about patents; files containing blank patent forms; and so on.

Similarly, to find all details of orders placed in December, the stacking of the "orders placed" and the "December" cards is all that is needed. If the substitution of the "January" card for the "December" card results in twenty holes appearing instead of thirty, then obviously sales have dropped in January. Comparisons month by month, area by area, industry by industry, and so on can be made with equal speed and significant statistics obtained.

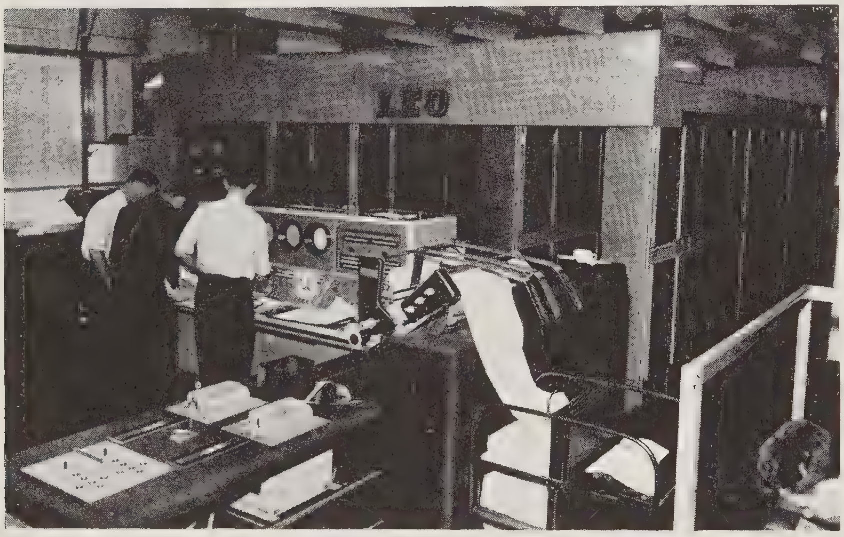
Again, if it is desired to circulate details of an improvement in a given product, all the people who have in the past shown interest in that product can be found by stacking together the product card and a "personal" card.

This system has now been in use for more than a year. It has proved very simple to run. It enables the present position of business to be seen at a glance from many aspects; it enables material of all types on any given subject to be assembled rapidly whenever required, this without the need to consult cross-references or other indexes; it makes filing very easy, since all items are kept according to one straightforward numerical order; and it can expand.

Other examples of the use of feature cards might have been taken—to mention a few—from the fields of librarianship, personnel selection, biological research, the maintenance of membership records and the forecasting of sales. In all cases the cards' characteristic advantages remain: great speed of search; ease of use; compactness; meaningfulness to the eye; and low cost.

Leo in action as a sales administrator

From orders collected by salesmen who make weekly calls on retailers, a Leo computer automatically produces all the necessary packing documents for the warehouse, sales statistics, reports revealing dormant customers, cash-collection lists, figures showing the efficiency and commission earned by each salesman and banking statements by which financial control over the entire operation is maintained. By putting this work on Leo the cost of preparing the necessary documents has been reduced by 25 per cent—this in addition to the management being in the happy position of being able to keep its finger on the pulse of this side of its business. The article below describes in detail the data processing methods used.



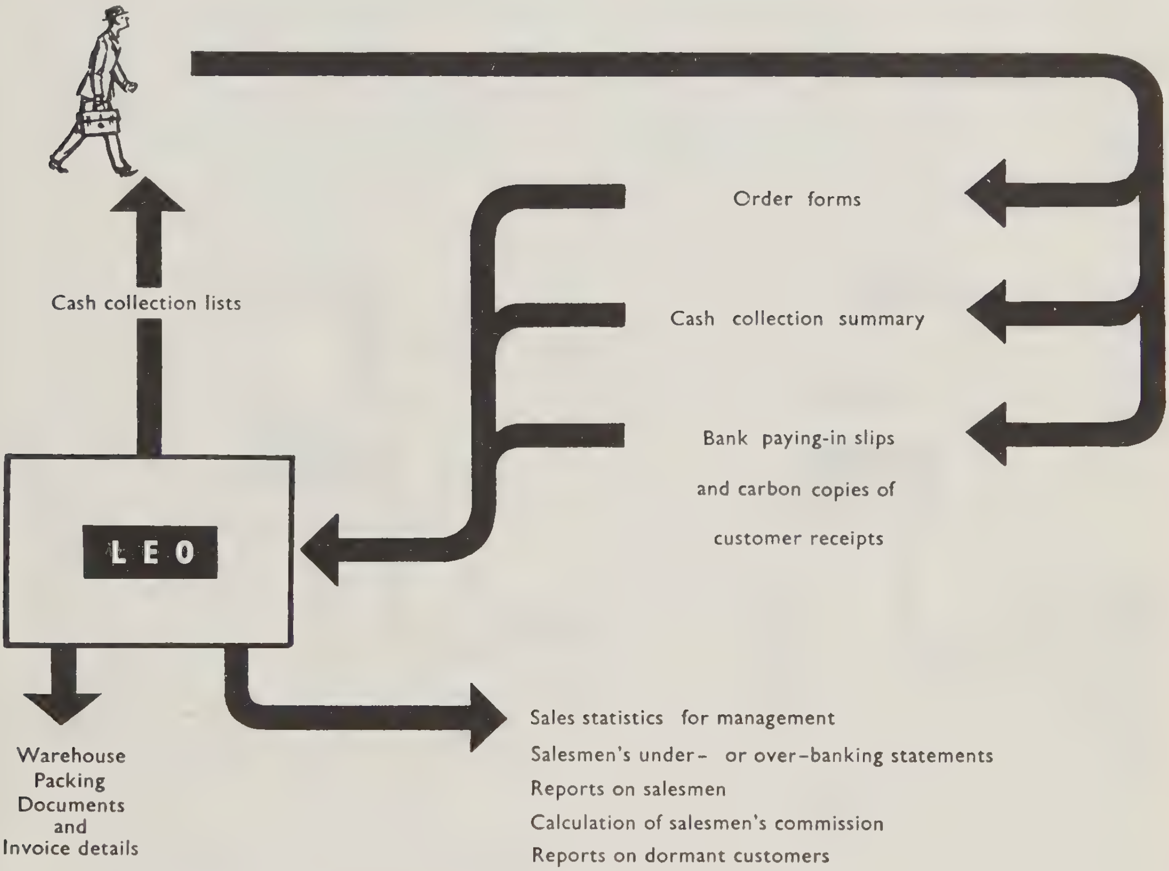
Leo II. This computer is approximately three times faster than Leo I from which it was developed

THE control of the sales of bakery products by J. Lyons & Co., Ltd., has been a regular daily job performed by Leo computers since January, 1956. All the documentation and necessary information is prepared on either the original Leo I computer situated at Cadby Hall or the much faster Leo II computer in Elms House nearby.

Briefly, the sequence of operations is this:—Lyons' bakery produces a range of packaged products, up to 100 in number, that are ordered by numerous retail shops throughout the country. Each order has an average value of £2 15s. 0d. Once a week salesmen visit each shop in their areas to collect cash for orders delivered the previous week, and also to take new orders. Every salesman is provided with printed order forms on which are listed the complete range of bakery products. He records the quantities of each item ordered by the customer on one of these forms. At the end of the day completed order forms are posted to Cadby Hall.

Here the information on the forms is transcribed on to punched paper tape for entry into Leo. The subsequent data processing sequence is divided into four separate phases, that are identified as A, B, C and D.

In phase A the information derived from the order forms is entered into Leo, together with certain permanent data. From this information Leo calculates the value of each invoice, prints packing documents needed by the despatch warehouse to assemble the orders and, in addition, produces financial and statistical data that are recorded on punched cards. Data recorded on these cards are required in two subsequent computing phases, C and D.



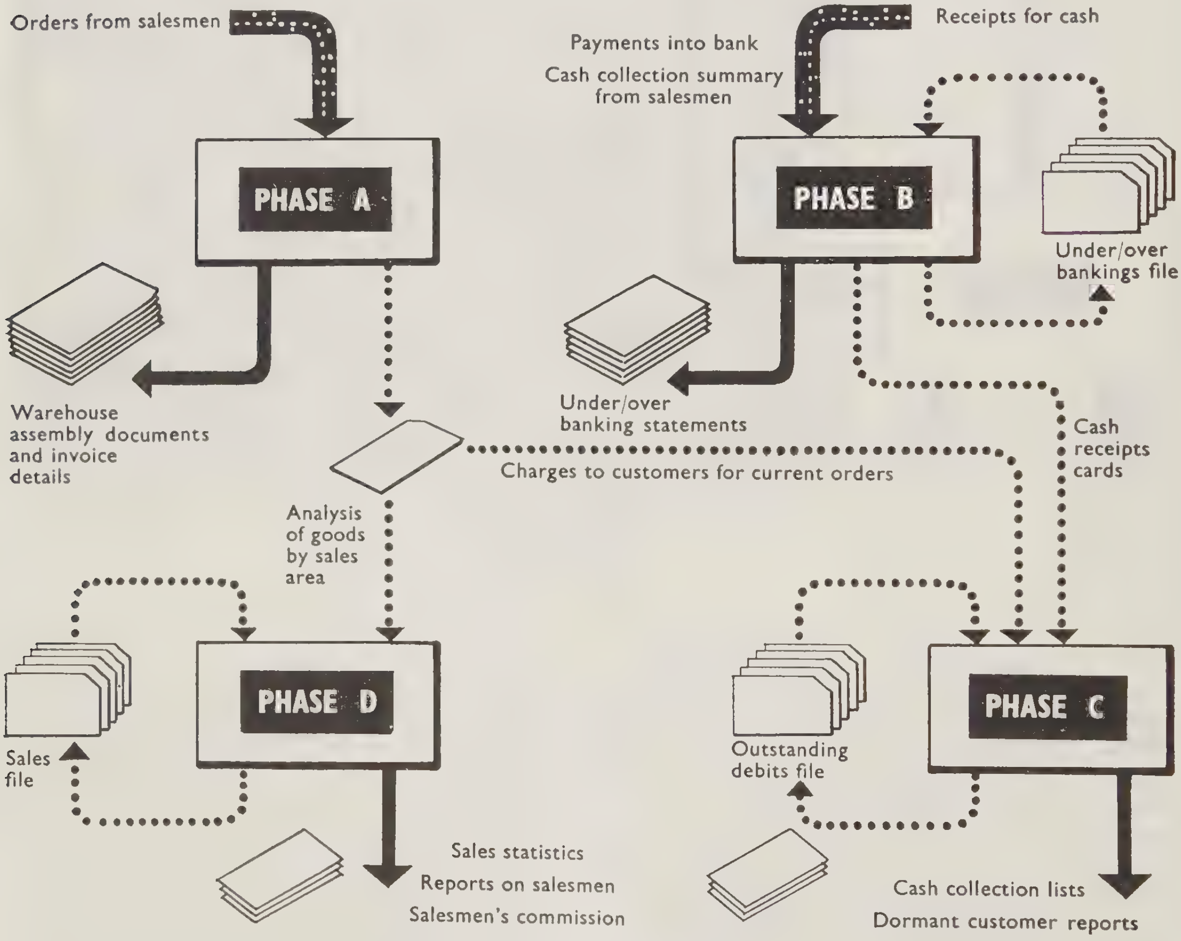
Phase B computations are concerned with maintaining financial control over the cash transactions. For this purpose the salesman sends to Cadby Hall other documents, in addition to the order forms. These are a cash-collection summary, carbon copies of all receipts given to customers for cash collected and a bank paying-in slip. He banks a proportion of the cash collected each day and records the value of cash received and banked on the cash-collection summary.

From these data and the information already held in a file of punched cards giving the previous banking balance, the computer can produce a new statement showing the current amount under- or over-banked by the salesman. In addition, sets of cards are punched giving details of the cash received from each customer and the new banking balance.

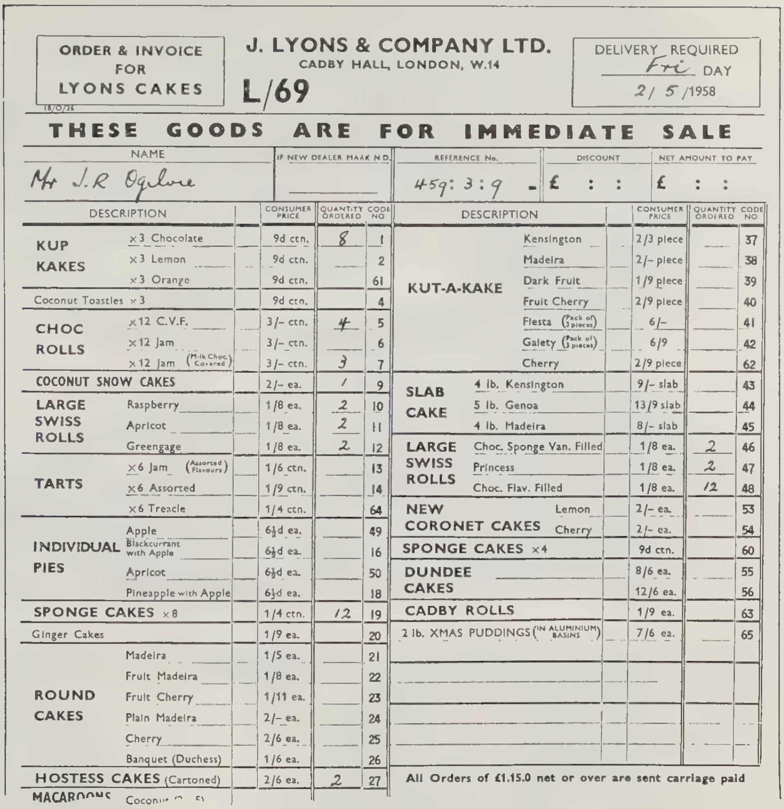
In phase C the punched cards produced from phase A showing the charges to be levied for current orders are read into Leo together with the cards listing the cash received from each customer. These latter cards are produced by the phase B operation. A file of punched cards that record debts still outstanding from previous weeks is also read into Leo. Documents automatically produced by Leo from these data are cash-collection lists specifying the money to be collected by the salesman from each customer at the time of the next weekly call. Another document produced during this phase is a report of dormant customers, that is customers who have not ordered bakery products recently. Phase D is an entirely different operation with a different object. Phases A, B and C are concerned principally with the day-to-day administrative work connected with bakery sales; in contrast, phase D provides sales statistics for the benefit of management. Punched cards produced by phase A are fed to the computer together with other punched cards on which accumulated data regarding previous sales are recorded. At the end of the phase D computation, a new set of updated cards is created for the file to be carried forward to the next week's operation. The punched cards carried forward from week-to-week constitute the permanent file of sales information. In addition to amendments to the file, significant sales statistics for the week and for the quarter, to date, are produced and, at intervals of one month, statements detailing the commission earned by each salesman are obtained. Reports are also given on all the salesmen.

The entire data processing sequence as described enables the management to maintain strict financial control over bakery sales without becoming enmeshed in detail. In addition, valuable sales statistical information is available shortly after the event, and this allows timely and appropriate action to be taken to counter adverse trends in the trading position. Also, all the documentation needed for the operation of the system is printed automatically.

Phases A, B and C, which are run on Leo every day, take approximately two hours to complete. Phase D is run once a week and takes, on average, 80 minutes. These are the times for the jobs when performed on Leo II.



Phases A, B and C are performed by Leo daily and Phase D once a week



ORDER & INVOICE
FOR
LYONS CAKES
18/0/26

J. LYONS & COMPANY LTD.
CADBY HALL, LONDON, W.14
L/69

DELIVERY REQUIRED
Fri DAY
2/ 5 /1958

THESE GOODS ARE FOR IMMEDIATE SALE

NAME	IF NEW DEALER MARK N.D.	REFERENCE No.	DISCOUNT	NET AMOUNT TO PAY
Mr J.R Ogilvie		459: 3: 9 -	£ : :	£ : :

DESCRIPTION			CONSUMER PRICE	QUANTITY ORDERED	CODE NO
KUP KAKES	×3 Chocolate		9d ctn.	8	1
	×3 Lemon		9d ctn.		2
	×3 Orange		9d ctn.		61
Coconut Toastles ×3			9d ctn.		4
CHOC ROLLS	×12 C.V.F.		3/- ctn.	4	5
	×12 Jam		3/- ctn.		6
	×12 Jam (Milk Choc. Covered)		3/- ctn.	3	7
COCONUT SNOW CAKES			2/- ea.	1	9
LARGE SWISS ROLLS	Raspberry		1/8 ea.	2	10
	Apricot		1/8 ea.	2	11
	Greengage		1/8 ea.	2	12
TARTS	×6 Jam (Assorted Flavours)		1/6 ctn.		13
	×6 Assorted		1/9 ctn.		14
	×6 Treacle		1/4 ctn.		64
INDIVIDUAL PIES	Apple		6½d ea.		49
	Blackcurrant with Apple		6½d ea.		16
	Apricot		6½d ea.		50
	Pineapple with Apple		6½d ea.		18
SPONGE CAKES ×8			1/4 ctn.	12	19
Ginger Cakes			1/9 ea.		20
ROUND CAKES	Madeira		1/5 ea.		21
	Fruit Madeira		1/8 ea.		22
	Fruit Cherry		1/11 ea.		23
	Plain Madeira		2/- ea.		24
	Cherry		2/6 ea.		25
	Banquet (Duchess)		1/6 ea.		26
HOSTESS CAKES (Cartoned)			2/6 ea.	2	27
MACAROONS	Coconu				

DESCRIPTION			CONSUMER PRICE	QUANTITY ORDERED	CODE NO.
KUT-A-KAKE	Kensington		2/3 piece		37
	Madeira		2/- piece		38
	Dark Fruit		1/9 piece		39
	Fruit Cherry		2/9 piece		40
	Fiesta (Pack of 3 pieces)		6/-		41
	Gaiety (Pack of 3 pieces)		6/9		42
	Cherry		2/9 piece		62
SLAB CAKE	4 lb. Kensington		9/- slab		43
	5 lb. Genoa		13/9 slab		44
	4 lb. Madeira		8/- slab		45
LARGE SWISS ROLLS	Choc. Sponge Van. Filled		1/8 ea.	2	46
	Princess		1/8 ea.	2	47
	Choc. Flav. Filled		1/8 ea.	12	48
NEW CORONET CAKES	Lemon		2/- ea.		53
	Cherry		2/- ea.		54
SPONGE CAKES ×4			9d ctn.		60
DUNDEE CAKES			8/6 ea.		55
			12/6 ea.		56
CADBY ROLLS			1/9 ea.		63
2 lb. XMAS PUDDINGS (IN ALUMINIUM BASINS)			7/6 ea.		65

All Orders of £1.15.0 net or over are sent carriage paid

Quantities of bakery products ordered by a customer are entered on a special form, part of which is shown here

In regard to the figures quoted, it has to be added that the documentation and statistics are prepared for three sales areas. These three districts contain about 70 salesmen who take some 2,000 orders each day. Distribution of packaged bakery products in other sales areas is administered by local centres and consequently the orders are not sent to Cadby Hall.

By performing the bakery sales work on Leo the cost of preparing the necessary documents has been reduced by 25 per cent. In addition, a considerable quantity of pertinent sales information is produced at the same time.

Before the data processing sequence is described in greater detail, something must be said about the two Leo computers that perform this work. Leo I is the original machine and was designed from the beginning with the object of efficiently processing commercial data. This philosophy at the time the specification for Leo was laid down was unusual as most electronic computers of the day were built solely as mathematical calculating machines. Leo I has been operating on commercial work since 1953.

A more fully developed version of the machine known as Leo II* was installed at Elms House in March, 1957. Leo II is approximately three times faster than Leo I; it is also more flexible in operation. Many large payrolls have been prepared on this machine on a weekly basis for such companies as Kodak, Ford, Stewarts and Lloyds and, of course, Lyons. Bakery sales work is normally performed on Leo I, because Leo II is used principally to provide a computing service for outside users.

Although J. Lyons & Co., Ltd., developed and built the original machine for their own use, a separate company was formed in 1955 called Leo Computers, Ltd., which manufactures and sells Leo computers in addition to providing a computer service. Five machines are now in operation in Great Britain; the latest one was supplied to the Ford Motor Company for controlling some 40,000 items held in stock

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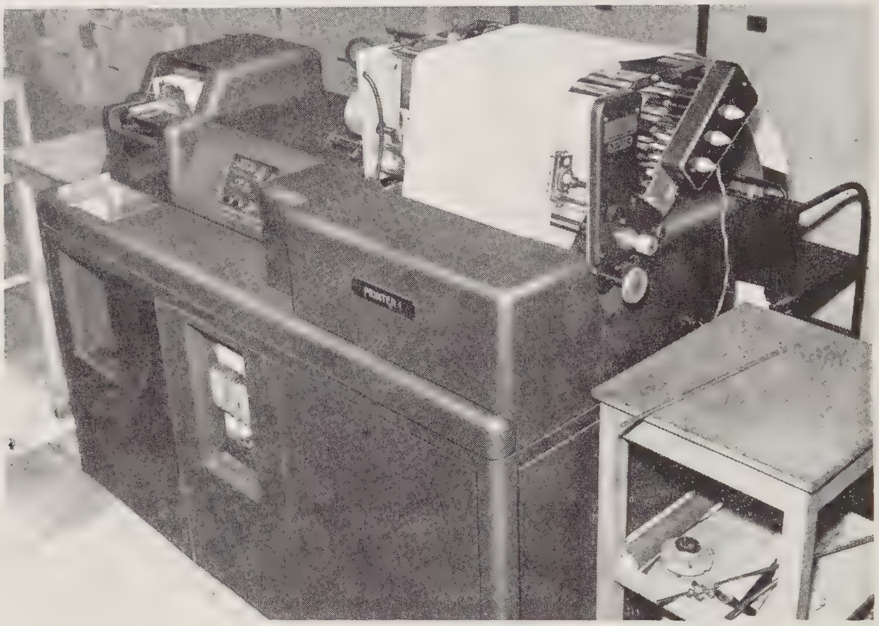
*A short description of this machine appears on pages 40 and 41 of the January-March, 1959, issue of *Data Processing*.

Transcribing data on to punched tape. The operator on the left is verifying data entered on the tape by the operator on the right



Documents are produced by this modified Hollerith tabulator connected to Leo. The printing speed is 100 lines a minute

at their Parts Division at Aveley. Other companies owning Leo II computers are the Imperial Tobacco Company, and the steel company of Stewarts and Lloyds Limited.

As already mentioned, up to 100 separate bakery items are produced, but the number manufactured at any one time will vary according to the season; therefore a current order form contains something less than 100 items. All information in Leo is portrayed in binary code†, but on the order form each bakery item is identified by an ordinary—decimal—number. The salesman enters the number of units of each bakery item ordered by the customer in the quantity column. A separate order form is prepared for each customer and a reference number identifying the particular customer is entered in the heading. The day on which delivery is required is also given. At Cadby Hall the orders are sorted into the delivery day sequence so that the appropriate information can be supplied to Leo on the day preceding despatch. Certain columns on the order form are enclosed in double rules. All information between these double rules has to be transcribed on to punched paper tape for introduction into the computer. Such information is the reference number of the customer, the bakery products' code numbers and quantities required.

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†See "The Universal Language of Computing," *Data Processing*, January-March, 1959, page 18.

Information is recorded in five-row paper tape by the manual operation of a tape perforating machine. The punched tape produced is then verified. Verification is performed manually on another tape perforating machine. The first punched paper tape, which is white, is fed into the verifying machine. An operator enters the information from the salesmen's orders in the same sequence as was adopted by the first operator.

As this is done, the original white tape is fed through the machine and so long as the information entered on the keyboard by the second operator agrees with the information punched in the white tape, a second tape is perforated that is an exact copy of the first. This second tape is blue in colour. Should a discrepancy occur between the two sources of information, the keyboard of the verifying machine locks automatically and a red light goes on to indicate that an error has been detected. The information entered on the white tape and that on the keyboard are then checked against the data on the order form and the correct value is punched into the blue tape.

Checking input data

A checking tape is also produced by the verifying machine. On this are printed all the characters entered on the keyboard. Every time the keyboard is locked because of an error, a red asterisk is printed on the checking tape. As a further precaution to ensure that all errors detected are properly corrected, the white perforated tape, the blue verified tape, the printed checking tape and the order forms are examined by a scrutineer. The scrutineer inspects to see that every item following a red asterisk has been correctly entered upon the blue paper tape. The blue tape is then accepted as a true and accurate document suitable for entering information into the computer.

An average of 7,500 verified characters an hour can be punched by two operators. Higher speeds of up to 10,000 verified characters an hour can be achieved by a good team.

The computer programmes that control the various phases are contained in packs of punched cards. The programme is read into the computer store as the first operation in any phase. Each of these 80-column cards contains 16 programme instructions and the cards are read at the rate of 200 a minute.

Phase A computation

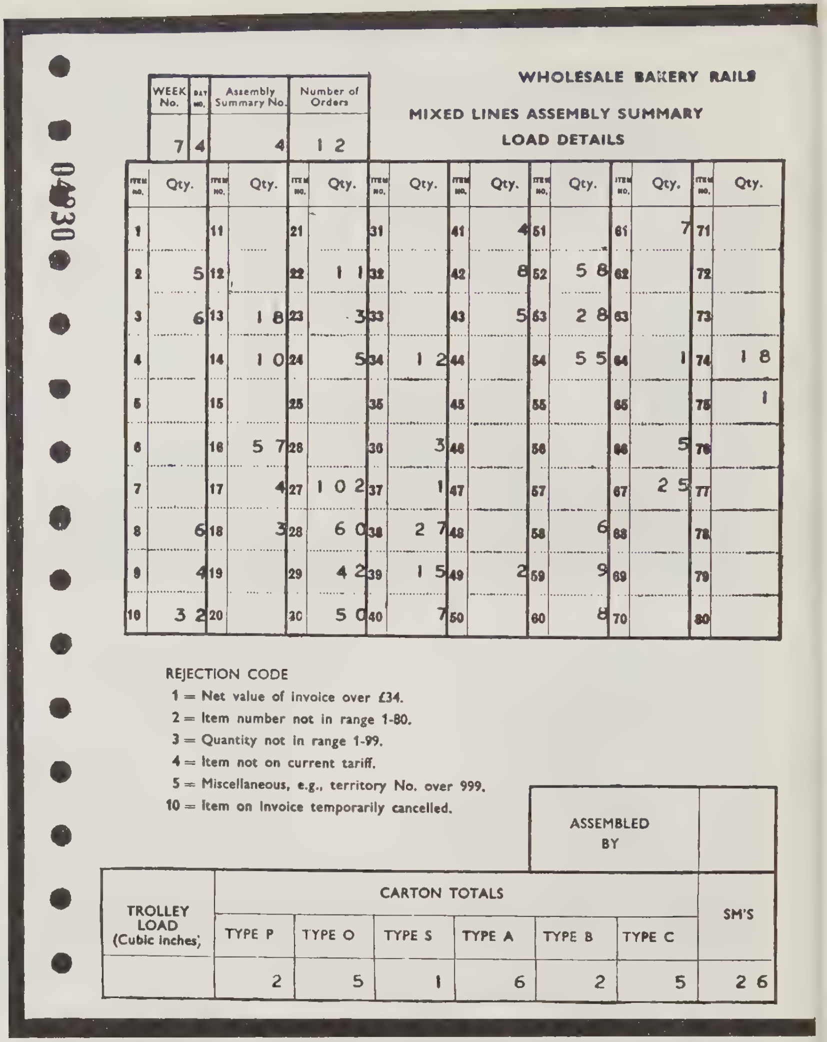
It will be recalled that the object of the phase A computation is to produce, from the information on the order forms, packaging information for the despatch warehouse, details of the cash to be debited to the customer, and sales to be credited to the salesman.

A set of punched cards containing the basic permanent factors and the tables associated with the calculations for phase A are entered after the programme. These cards list such items as the volume of each bakery item in cubic inches, the price of each item, the discount rate and information as to the most suitable carton, or combination of cartons, into which a particular order can be packed.

Each punched card contains the data relating to ten commodities. Consequently, all the fixed information for the complete range of bakery products handled can be entered on up to ten cards. The information concerning any one item is recorded in binary code on one horizontal line across the width of the standard 80-column card. Check totals are entered in the final line on the card. These totals are used to confirm automatically that the values on each card have been correctly read before being passed into the computer information store.

Data concerning actual orders, transcribed and recorded on the blue punched paper tape, are then fed into the computer. The paper tape input unit is equipped with two Ferranti photo-electric reading heads that operate at 200 characters a second. The heads are used alternately. As one tape is being read by one head a new tape is being fitted to the other, thus there is no delay in entering information into the computer.

Information derived within the computer during phase A is recorded on two printed documents and also on punched cards. The two printed documents are both used in the warehouse to assemble and despatch the orders. The



WEEK No.	DAY NO.	Assembly Summary No.	Number of Orders
7	4	4	1 2

WHOLESALE BAKERY RAILS

MIXED LINES ASSEMBLY SUMMARY

LOAD DETAILS

ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.	ITEM NO.	Qty.
1		11		21		31		41	4	51		61	7	71	
2	5	12		22	1 1	32		42	8	52	5 8	62		72	
3	6	13	1 8	23	3	33		43	5	53	2 8	63		73	
4		14	1 0	24	5	34	1 2	44		54	5 5	64	1	74	1 8
5		15		25		35		45		55		65		75	1
6		16	5 7	26		36	3	46		56		66	5	76	
7		17	4	27	1 0 2	37	1	47		57		67	2 5	77	
8	6	18	3	28	6 0	38	2 7	48		58	6	68		78	
9	4	19		29	4 2	39	1 5	49	2	59	9	69		79	
10	3 2	20		30	5 0	40	7	50		60	8	70		80	

REJECTION CODE
1 = Net value of invoice over £34.
2 = Item number not in range 1-80.
3 = Quantity not in range 1-99.
4 = Item not on current tariff.
5 = Miscellaneous, e.g., territory No. over 999.
10 = Item on invoice temporarily cancelled.

ASSEMBLED BY

TROLLEY LOAD (Cubic inches)	CARTON TOTALS						SM'S
	TYPE P	TYPE O	TYPE S	TYPE A	TYPE B	TYPE C	
	2	5	1	6	2	5	2 6

A pair of packing documents printed by Leo. Orders listed on any given pair are sufficient to fill one warehouse assembly trolley of 45,000 *cubic inches capacity. Bulk requirements of individual bakery products are given in the document shown on the left*

(Bottom right) Another item of punched card machinery connected to Leo to record output data—a card punch that operates at a speed of 100 *cards a minute*

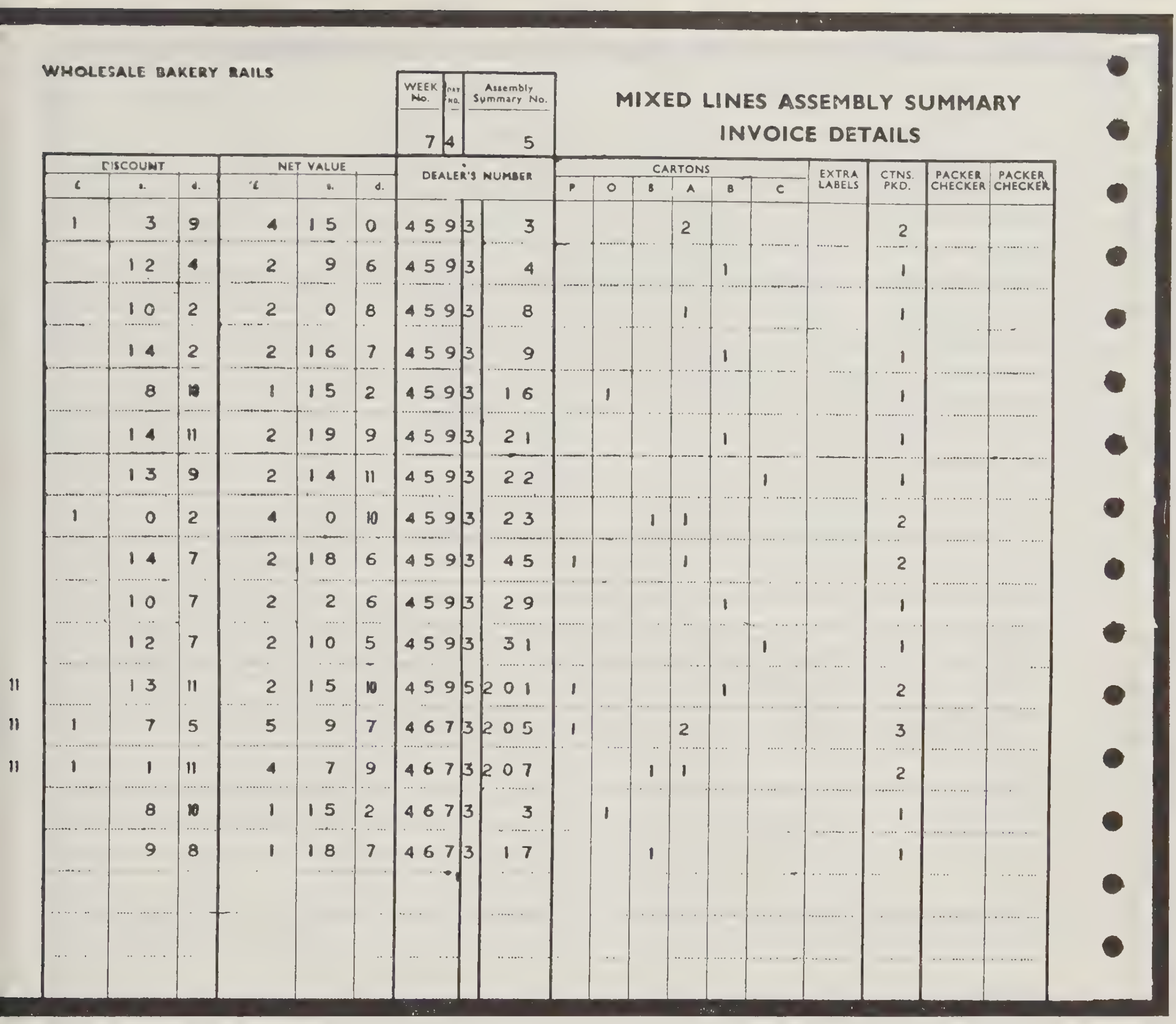
first of the documents is headed by a week number (tax week), despatch day (1 to 5 representing Monday to Friday) and an assembly summary number for reference purposes. In the main portion of the document is a list of customer code numbers and the net values of the orders and the cash discounts allowed.

The centre digit of each customer's number indicates the day of the week on which the salesman normally calls. Salesmen, however, can, and do, call on customers on other days if this is necessary. Printed on the same line against the code number of the customer, is information on the types of carton required to contain the order, together with the total number of cartons that comprise each order. Every order can be packed in one or other, or a combination, of six cartons.

The number of orders printed on each packing sheet is determined by the maximum volume of goods that can be assembled and transported on the standard trolleys used in the despatch warehouse. This volume is 45,000 cubic inches.

As the figures for each order are processed by the computer a running total of the volume occupied by the packages is maintained and as soon as the next order would cause this value to exceed 45,000 cubic inches, that particular batch of orders is printed out. All this is done by the computer automatically.

On the second document produced is listed the individual totals of bakery items identified by their code numbers, together with information as to the various sizes of carton required to be loaded on to each trolley for transportation to the packing department. This form also



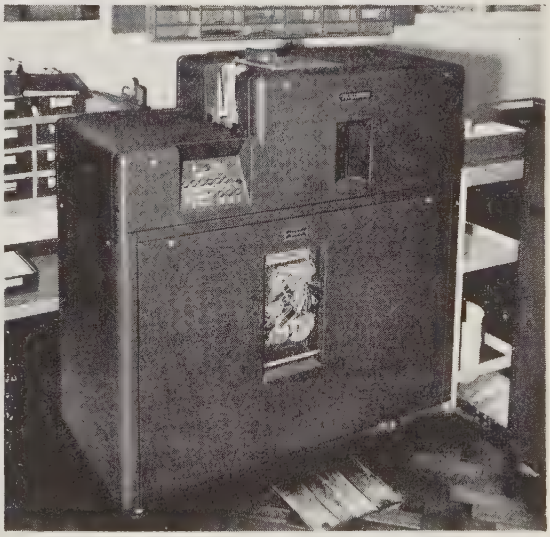
WHOLESALE BAKERY RAILS

WEEK No.	DAY No.	Assembly Summary No.
7	4	5

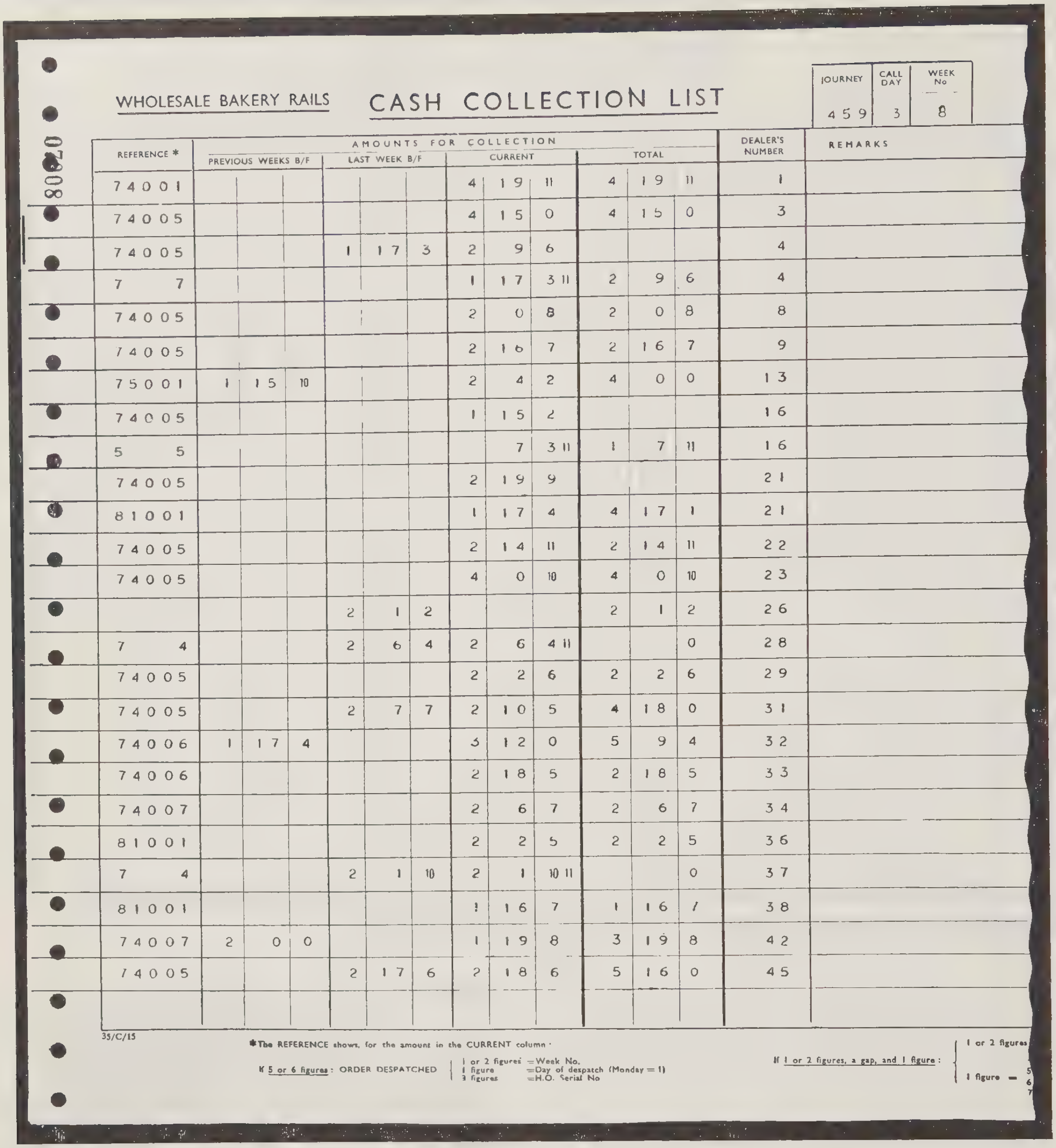
MIXED LINES ASSEMBLY SUMMARY
INVOICE DETAILS

	DISCOUNT			NET VALUE			DEALER'S NUMBER			CARTONS						EXTRA LABELS	CTNS. PKD.	PACKER CHECKER	PACKER CHECKER
	£	s.	d.	£	s.	d.				P	O	S	A	B	C				
	1	3	9	4	15	0	459	3	3				2				2		
		12	4	2	9	6	459	3	4					1			1		
		10	2	2	0	8	459	3	8				1				1		
		14	2	2	16	7	459	3	9					1			1		
		8	10	1	15	2	459	3	16		1						1		
		14	11	2	19	9	459	3	21					1			1		
		13	9	2	14	11	459	3	22						1		1		
	1	0	2	4	0	10	459	3	23			1	1				2		
		14	7	2	18	6	459	3	45	1			1				2		
		10	7	2	2	6	459	3	29					1			1		
		12	7	2	10	5	459	3	31						1		1		
11		13	11	2	15	10	459	5	201	1				1			2		
11	1	7	5	5	9	7	467	3	205	1			2				3		
11	1	1	11	4	7	9	467	3	207			1	1				2		
		8	10	1	15	2	467	3	3		1						1		
		9	8	1	18	7	467	3	17			1					1		

carries the standard information such as week number, day number and assembly summary number. In addition, the time allowed for the warehouseman to assemble one batch of orders on a trolley is computed and printed on the form for bonus payment purposes. These two documents are printed by a modified Hollerith tabulator that operates at a rate of 100 lines a minute.



The other documents on which the output from phase A is recorded are punched cards. Cards are punched at the rate of 100 a minute. With this computer system it is customary for all information that has to be carried forward from week to week, or to other phases of the data processing sequence, to be recorded on punched cards. Each punched card produced from phase A contains information on the cash to be debited to each customer's account, the sales-



WHOLESALE BAKERY RAILS

CASH COLLECTION LIST

JOURNEY	CALL DAY	WEEK No
4 5 9	3	8

REFERENCE *	AMOUNTS FOR COLLECTION												DEALER'S NUMBER	REMARKS
	PREVIOUS WEEKS B/F			LAST WEEK B/F			CURRENT			TOTAL				
74001							4	19	11	4	19	11	1	
74005							4	15	0	4	15	0	3	
74005				1	17	3	2	9	6				4	
7 7							1	17	3 11	2	9	6	4	
74005							2	0	8	2	0	8	8	
74005							2	16	7	2	16	7	9	
75001	1	15	10				2	4	2	4	0	0	13	
74005							1	15	2				16	
5 5								7	3 11	1	7	11	16	
74005							2	19	9				21	
81001							1	17	4	4	17	1	21	
74005							2	14	11	2	14	11	22	
74005							4	0	10	4	0	10	23	
				2	1	2				2	1	2	26	
7 4				2	6	4	2	6	4 11			0	28	
74005							2	2	6	2	2	6	29	
74005				2	7	7	2	10	5	4	18	0	31	
74006	1	17	4				3	12	0	5	9	4	32	
74006							2	18	5	2	18	5	33	
74007							2	6	7	2	6	7	34	
81001							2	2	5	2	2	5	36	
7 4				2	1	10	2	1	10 11			0	37	
81001							1	16	7	1	16	7	38	
74007	2	0	0				1	19	8	3	19	8	42	
74005				2	17	6	2	18	6	5	16	0	45	

35/C/15

*The REFERENCE shows, for the amount in the CURRENT column:

If 5 or 6 figures: ORDER DESPATCHED { 1 or 2 figures = Week No.; 1 figure = Day of despatch (Monday = 1); 3 figures = H.O. Serial No

If 1 or 2 figures, a gap, and 1 figure: { 1 or 2 figures; 1 figure — 5 6 7

Cash-collection list containing details of amounts due from each customer. Occasionally an entry relating to one customer occupies two lines. Where any pence column contains the number 11 *alongside the actual number of pence, this indicates that the particular entry has to be subtracted*

man who obtained the order and the quantity of each particular type of bakery product sold. Phase B of the computation maintains control over the financial aspects of the operation. As already mentioned, printed statements of the under- or over-banking of cash by each salesman are produced. In addition the current under- or over-banking balance of each salesman is recorded on punched cards to be filed and carried forward to the next day's run. Details of cash actually collected from customers is also recorded on punched cards. These latter cards are then sorted into the daily order in which the calls are made and are used as an input to the subsequent phase C operation when the cash-collection lists are compiled for the salesmen.

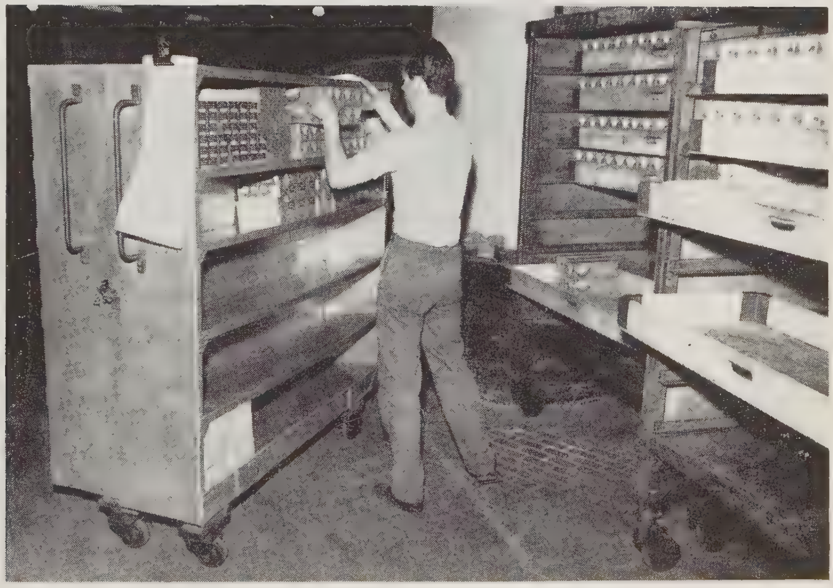
Input data for the phase B calculation are provided from two sources. One is the punched cards of the under- or over-banking file produced by the phase B operation of the previous day. The second source is a number of written documents prepared and returned daily by the salesman. One of these documents is the cash-collection summary on which is shown the cash banked up to bank closing time and any additional amounts held back to be paid in on the next day. Other documents are the bank paying-in slip and carbon copies of all receipts issued to customers. On these latter documents the salesman records any variations between the amounts due and the amounts collected. He may make an allowance, not exceeding 5s., for goods damaged in transit.

Data on the cash-collection summary, bank paying-in slip and customer receipts are transcribed on to punched paper tape. In this run, the computer is largely occupied in reconciling these various items of information, one with another. The figures on the bank paying-in slip are checked against the "cash banked" amount on the cash-collection summary (they will later be manually checked with the bank statement). Total cash received according to the cash-collection summary is verified by comparing it with the total of the individual carbon receipts. Even the arithmetical accuracy of the summary itself is checked by the computer, and any errors are reported on the printed statement produced. This is prepared daily for each salesman and shows his under- or over-banking to date, plus details of any adjustments to be made in respect of errors on the cash-collection summary. A record of the cash received from the customers is made on punched cards. Also the current under- or over-banking balance for each salesman is recorded on punched cards to be carried forward to the next day's run.

Basic data for phase C are provided by the punched cards obtained from phases A and B plus those cards from the previous phase C run that list amounts of cash overdue. Phase B cards contain details of cash collected from customers. As stated, the object of this phase is to produce cash-collection lists that are sent to the salesmen, also lists of customers who have failed to re-order bakery products. In addition, outstanding amounts still not cleared by customers are punched out on cards to be carried forward to the phase C operation of the following week.

The cash-collection list for a particular day is produced three days before the salesman is due to make the calls so that it can be posted to him and he will receive it in good time. On it, of course, is entered the money due to be collected from each customer as a result of the order placed during the previous week and already delivered, plus any other amounts outstanding. These figures are listed separately and the total

Loading bulk requirements of each bakery product for one complete group of orders on to a warehouse trolley



amount owing is printed in a totals column. Other information produced in documentary form are lists of customers who have not re-ordered bakery products for 4, 8, 12 or 16 weeks. This enables sales management to investigate the reasons and, where appropriate, to take corrective action.

These three phases conclude the main data processing sequence. Phase D—the fourth computer run—is concerned with providing sales statistics for management and calculating the monthly commission due to each salesman.

Punched cards produced by phase A are used as input data together with a set of punched cards which function as a file and contain all the sales statistical information up to the previous week. The file cards also contain a certain proportion of permanent data such as the sales quotas for the various districts and also for the individual salesmen.

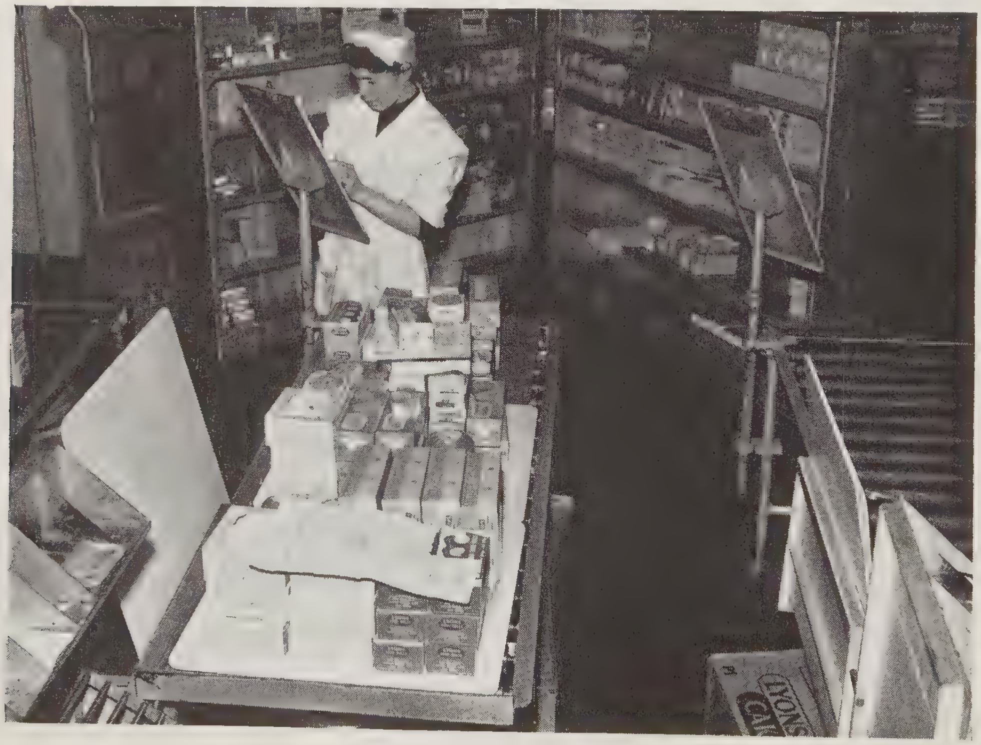
Information produced in documentary form during this phase comprises sales statistical data; these include weekly, monthly and quarterly reports on salesmen. For salesmen who exceed their monthly quota the commission earned is calculated. Sales statistics by districts are also derived giving the cash value of all sales and the types of bakery item sold. This latter information is obtained so quickly that the sales management can take effective action to adjust production or correct an adverse sales trend. In addition cards are punched that constitute the new sales statistics file updated with the current week's figures. These cards will be carried forward to the following week and will provide the input to the next phase D operation.

Packing and despatch

This concludes the data processing sequence on Leo for this particular bakery sales operation, but the method of packing and despatching the goods is of interest, because in this, too, the minimum of manual clerical work is performed.

First, the printed documents produced by phase A are sent to the warehouse. These provide the necessary authority and all the relevant information for despatching the goods. The warehouseman is given a set of documents that consist of all the individual handwritten orders sent in by the salesman, plus the packing documents produced by Leo that list gross quantities of each bakery product for the particular group of orders. He moves a trolley from one storage location to the next and loads the gross quantities of each item listed.

Checking the invoice previous to packing individual orders in the appropriate cartons



Over 5,000 *individual orders a day are assembled in the packing department. The documents for* 2,000 *of these are prepared automatically by Leo*

When all the items have been assembled the trolley should be almost filled to capacity (45,000 cubic inches). The trolley is then taken by lift to the next floor of the warehouse and here the correct number and types of cardboard cartons to contain the orders are loaded on top. As mentioned earlier, the numbers and types of carton required are given on the assembly document produced by Leo.

The loaded trolley is positioned at the end of a short roller conveyor where girls, working in pairs, assemble and pack the individual orders. The first girl selects the items from the trolley that go to make up one particular order. She checks these off on the salesman's order form. This document is now used as the invoice to the customer. The second girl packs these items into the appropriate containers. Completed containers are placed on a moving conveyor and transported to a room where they are closed by wire-stitching. They are then replaced on the conveyor and transported to the lorry loading bay, where a member of British Railways marks each box as it passes, to indicate to which goods station each particular package is to be taken according to the destination printed on the address label. The cartons are loaded directly on to the appropriate lorries drawn up in the loading bay. Over 5,000 individual orders, of which 2,000 are prepared by Leo, are dealt with each day by 20 pairs, or teams, of packers.

An interesting point is that the salesman's order form, the primary document, is made to perform several functions and thus there is no need for a large number of copies. Initially, information on the order form is transcribed on to punched tape for use in the computer, which, in phase A, calculated the discount and net value to be charged to the customer. This value is entered manually upon the order form. No individual item values are recorded, only the total.

Finally, the order form is microfilmed and this is the only record of the transaction kept by Lyons. Incidentally, before the form is sent to the warehouse the address label for the container is attached. These labels are prepared automatically by an Addressograph machine from master stencils held on file.

The data processing system just described surely must be one of the best examples of a truly integrated system in current operation.

A machine that learns

First practical application of the principle of mechanical learning: highly ingenious, yet simple technique with apparently immense potentialities in both business and industry

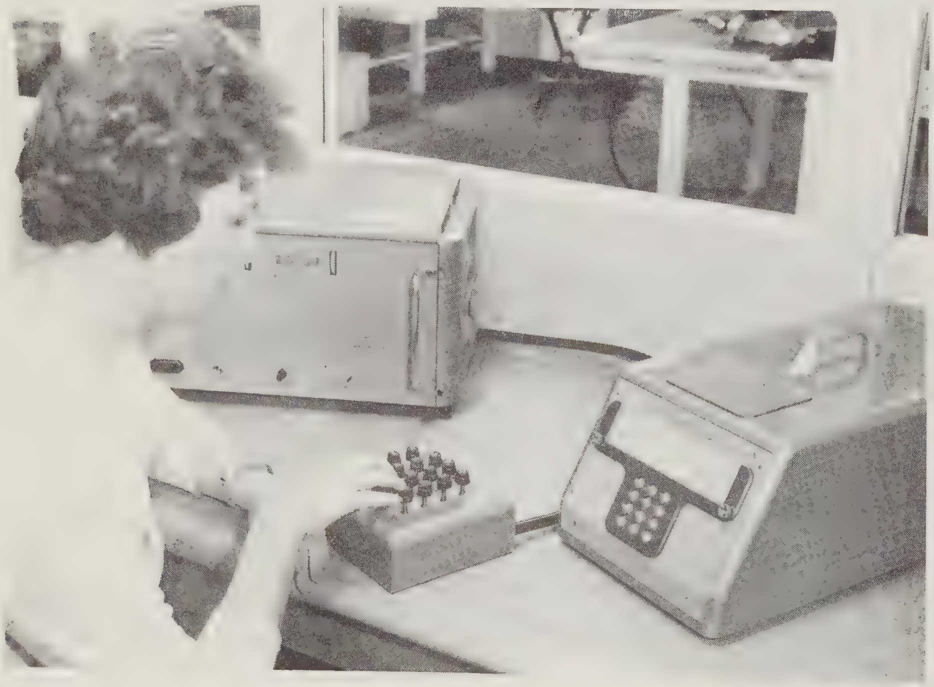
At present this "mechanical thinking" is employed by Solartron in their automatic keyboard instructor, which is estimated to reduce the cost of keyboard training by well over 60 per cent. As the pupil becomes more efficient, the tempo of the exercises increases; if the pupil has difficulty over a particular part, not only is the speed reduced automatically but also the machine helps by visual aids; in the later stages of the tuition the machine forces the pupil to concentrate on those portions that have not been properly assimilated.

Since any improvement or deterioration in the individual's performance causes an immediate response from the machine, the pupil is automatically stimulated or helped, as the need may be—this without any supervision.

As the following article reveals, the machine's memory consists solely of 96 electrical condensers, one for each of the 96 positions in which characters appear on the exercise card.

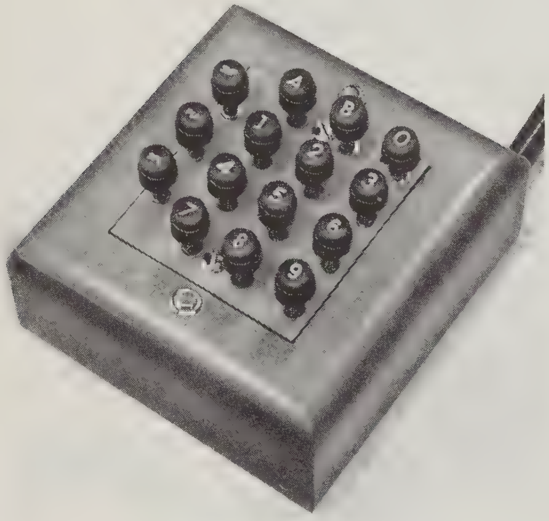
THE electronic digital computer had hardly been developed before the idea of machines that could "learn" from their own experience was being propounded. Usually ideas precede achievement by many years, yet even at this early stage a simple, valuable, and extremely practical application of the principle of mechanical learning exists. Indeed, already the firm concerned, the Solartron Electronic Group, Ltd., Thames Ditton, Surrey, have built and supplied, mainly to commercial companies, twelve teaching machines to train people to operate the keyboards of card punches.

A study of the design of these machines is useful not only because of the new approach to training people in manual skills, but also



Solartron Saki card-punch keyboard trainer is entirely automatic in operation

from experience

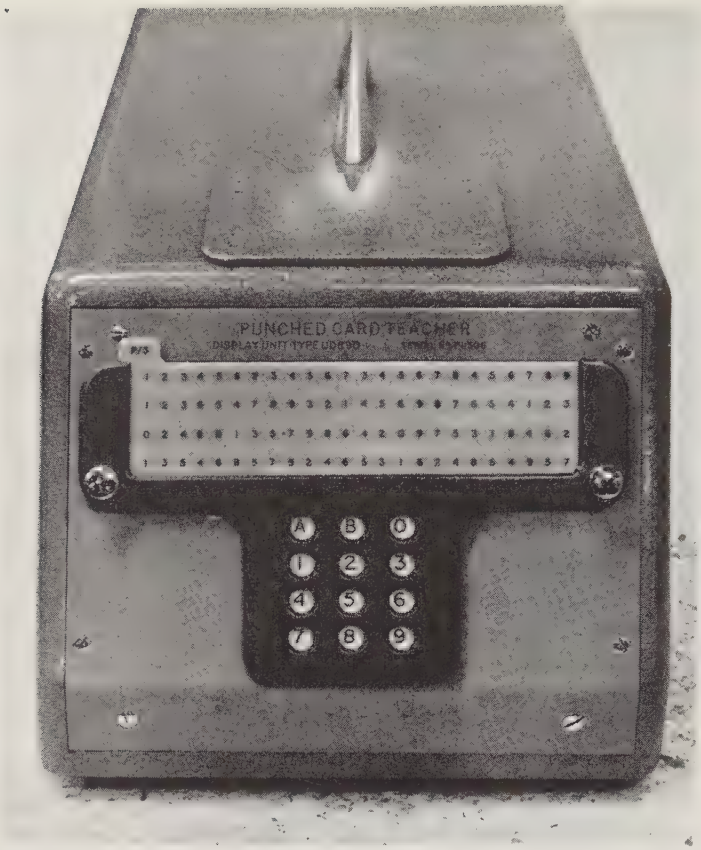


A Powers-Samas keyboard modified for use with the trainer

because the principles involved are capable of a far wider application. Undoubtedly, within the next decade, these techniques will be used increasingly for such tasks as providing automatic control in the continuous-processing industries. For such applications the management will specify the task and the machine itself will make all the detail "decisions" necessary and, continuously measuring the performance attained, will adjust the operation to maintain maximum efficiency. In this context, machines that possess the ability to learn will be capable of doing a considerable proportion of the work now carried out by supervisory staffs throughout industry.

The principle of mechanical learning can be used in a teaching machine because learning and teaching are, as it were, opposite faces of the same coin. While the pupil is being taught the instructor learns the capabilities of the pupil and modifies his training instructions accordingly. Hence the pupil acquires knowledge in the quickest and most efficient manner. This is precisely what is achieved by the Solartron automatic keyboard instructor (known in short from its initials as Saki). As the pupil becomes more proficient the lessons set by the machine become progressively more difficult.

On the left is a Hollerith card-punch keyboard and on the right an IBM keyboard. Both can be fitted to the trainer



The upper panel, containing four lines of figures, shows the exercise to be performed. The lower display panel provides a visual aid indicating the correct key to press. A Powers-Samas keyboard is shown

Should the pupil make a mistake the machine indicates the correct answer and proceeds to simplify the task set. In other words, the machine responds to the ability shown by the pupil and by always keeping one step in advance, but no more than one step, ensures that the individual learns at the maximum rate of which he or she—usually a "she"—is capable.

Saki consists of three units—the control unit, the display unit and the keyboard. The keyboard used is the actual one on which training is required and not a replica. Actual keyboards are modified to work with the remainder of the equipment so that the pupil obtains the correct "feel" of the keyboard to be operated. Typical keyboards for card-punching machines are illustrated. The teaching machine can be adapted to take Powers-Samas, IBM or Hollerith keyboards.

The display unit is fitted with two panels that can be illuminated. One panel, the lower one, carries a diagram of the keyboard and the upper panel is a translucent screen on which are printed four rows of characters. These may be either numerals or letters and cover the complete range of characters available on the keyboard. First, the operation of the machine will be described. The pupil sits in front of the machine and, when it is switched on, a light will appear behind the first character in the first line of the upper translucent panel of the display unit. These characters represent the exercise to be performed by the pupil and the first figure illuminated indicates that the pupil is to depress the key representing this character. To help the pupil to identify the correct key a light also appears behind one of the keys—the appropriate key on the lower display panel. When the pupil depresses the key indicated, the lights on both display panels will be extinguished and another light will appear behind the second character in the row containing the exercise. Simultaneously, the appropriate key to be pressed will be indicated on the lower panel. As the pupil depresses the required key the lights are extinguished and the next character on the exercise display panel will be illuminated.

This sequence of operation continues. The pupil follows the exercise set by the rows of characters printed on the upper display panel as they are illuminated in turn, assisted by the visual display on the lower panel that helps her to select the correct key. As the response of the pupil becomes faster, the rate at which the characters in the exercise are presented by the machine is increased automatically.

As the pupil becomes even more proficient, the lights that appear on the lower display panel begin to get dimmer until finally they go out. At this stage then, the visual assistance given to the pupil in selecting the correct key is withdrawn and should she not have learnt the disposition of the keys by this time, sooner or later she will make a mistake and depress the wrong key. Immediately this happens the machine slows down and the lights showing the correct keys to be pressed reappear.

From this description it can be seen that the teaching machine modifies its response to suit the skill of the pupil. As proficiency improves, so first the speed at which the exercise has to be performed is increased and, secondly, the visual assistance given in selecting the correct key is discontinued.

The complete exercise shown on the upper display panel contains four lines, each of 24 characters. The first line naturally starts off with easy sequences of the keyboard characters and these sequences grow more complex until the final line will be a completely random selection of the characters available. When the end of one line is reached, the machine returns to the beginning of the same line and repeats it; the machine does not start on the next line.

Proficiency

Until the pupil is proficient, the original line is repeated continuously. When the pupil is able to repeat the exercise line correctly and has reached a certain speed of operation she is judged to be proficient on this line and the machine will switch automatically to the next slightly more difficult line. This training sequence continues until the final line is reached.

With this method the pupil is always presented with a challenge. She competes with the machine, attempting to keep the lights out. Should she start making mistakes, the machine immediately slows down and the lights of the keyboard display reappear to assist and encourage her to have another try. The performance of a pupil is assessed from two counters, fitted in the control unit, that record the number of correct keyboard depressions made during a training session and also the number of incorrect ones.

It is not claimed that the machine can train card-punch operators completely because the job involves more than just the correct operation of a keyboard, but it is claimed that it does teach a pupil accurate fingering and the disposition of the keys on the keyboard. A preliminary estimate suggests that one hour's training on Saki is the equivalent of three hours' training using conventional methods that require human supervision.

Other advantages are claimed. One is that it eliminates the need to verify—manually—actual cards punched, the number of correct and incorrect punchings being shown on the counters. Further, it teaches touch-typing from the beginning, since the operator watches the lights on the display panel and not the keyboard. Also only the minimum of human supervision is needed.

Training periods

From experience to date, it has been found that maximum benefit is obtained if each pupil uses the machine for about three-quarters of an hour at a stretch.

Exercises can be altered. The translucent card on which the four rows of characters of the exercise are printed can easily be removed and replaced by another card carrying a different exercise. At the same time the internal circuits of the machine have to be altered and this is done, quite simply, by removing a plug-in block, called the programme block, and replacing it by another. The programme block consists of eight printed circuit cards which make the appropriate electrical connections.

Saki, less the keyboard, but including one programme block, costs £575. A Powers-Samas keyboard to go with the machine costs £50, a Hollerith keyboard £60 and additional exercise programme blocks cost £8 each.

Although the principle of learning from experience is a complex one, the electronic circuits associated with this machine are simple. The memory, where the performance of the pupil is gauged, consists of 96 condensers, one for each of the 96 positions in which a character can be printed on the exercise card (four lines of 24). A rotary switch with contacts spaced around the periphery controls the action of the machine. When the start button is pressed the rotary switch moves to the first contact. This causes the bulb behind the first character of the exercise to be illuminated simultaneously with the bulb behind the appropriate key of the keyboard display. It also connects the circuit to the first of the 96 condensers. At the beginning of a training sequence all these condensers are uncharged. If the correct key is depressed a unit electrical charge is given to the condenser.

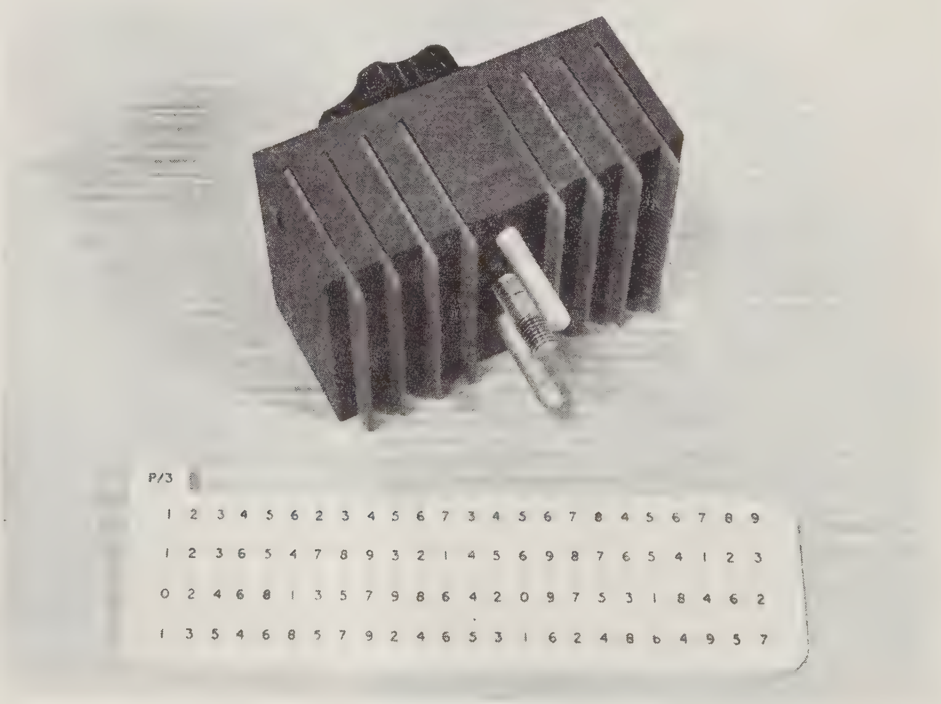
After the first action has been completed, the rotary switch receives an impulse and moves to the next, or second, contact. This switches on the bulb behind the second character of the exercise and also indicates the appropriate key on the keyboard diagram; it also switches into the circuit the second condenser of the memory.

Operating speed

An interval of four seconds is allowed for the pupil to select the appropriate key. Should a key not be depressed at the end of this time, the rotary switch is automatically indexed to the next position. This four-second frequency is the slowest speed at which the machine operates. As the exercise proceeds, an electrical charge builds up in each condenser; this effectively records the proficiency of the pupil in selecting the correct key for the character in that position on the exercise card. As the level of the electrical charge stored by a condenser increases so the intensity of the indicator light on the keyboard display is reduced until, when a certain level of charge is reached, the light is extinguished. Also, as the level of the electrical charge increases, the time allowed for the pupil to press the appropriate key is reduced.

Should the pupil press the wrong key, the particular condenser is discharged completely, wiping out all unit charges stored in that condenser from previous correct operations. This, of course, has the effect of bringing the light of the keyboard display back to full brightness; it also slows down the machine at this particular point in the exercise and allows the pupil the full four seconds in which to select the correct key.

A separate condenser is used to measure the average speed with which the pupil responds for all the characters presented on one line of the exercise. The level of charge built up in this condenser is a measure of the pupil's proficiency on that line. When this value reaches a certain limit, the machine automatically switches to the



The programme block and the associated exercise card

Programme blocks and exercise cards can be changed easily

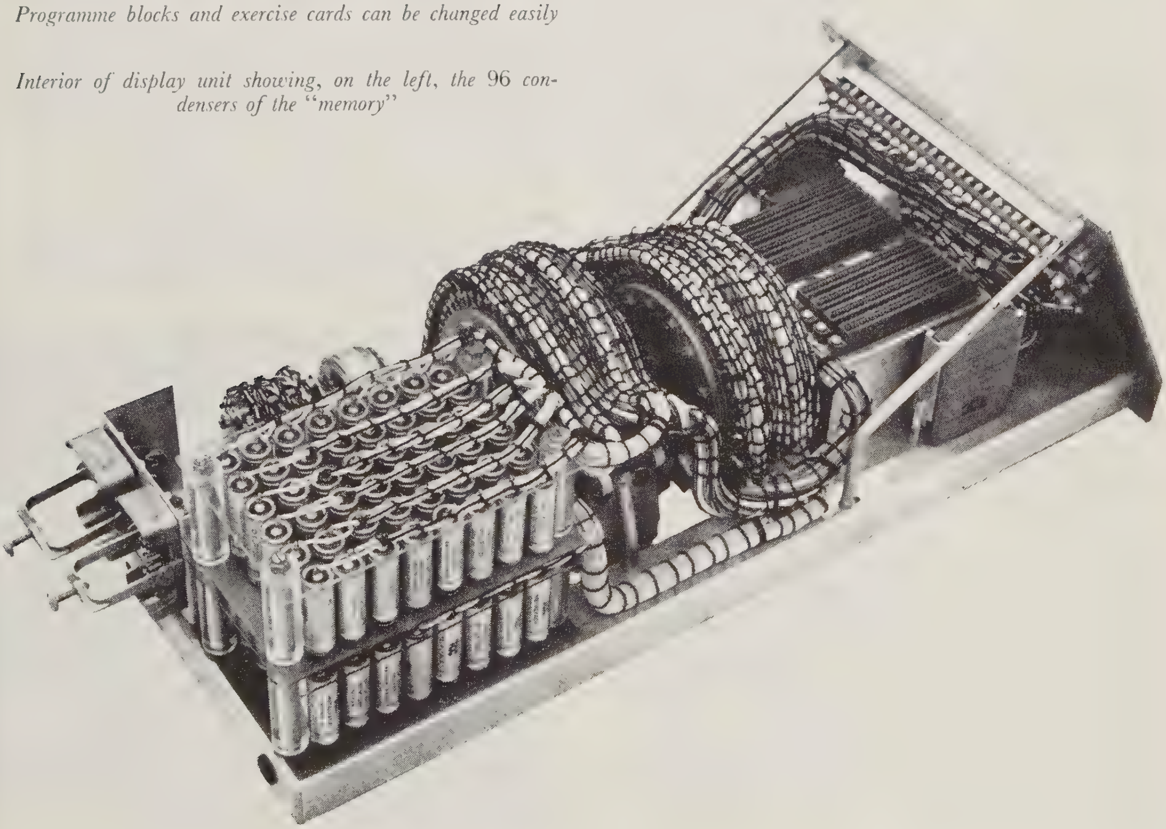
next line of the exercise. The actual level of charge at which this action will occur can be altered by a manual control placed at the back of the control cabinet. By adjustment of this control the degree of proficiency needed to change from one line of the exercise to the next can be made either higher or lower.

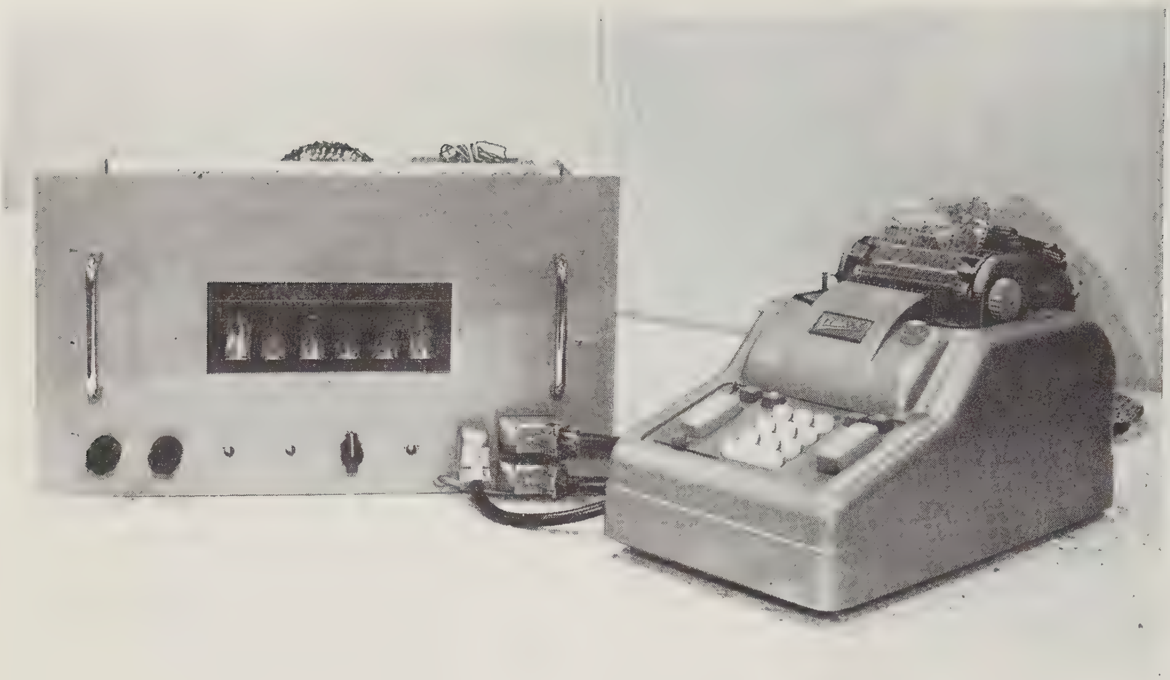
Maximum operating speed is six characters, or key depressions, per second. A good operator can exceed this speed for short periods, but since the machine is primarily intended to train people fresh to keyboard work this upper speed limitation is not significant.

To assist in the selection of personnel for training, provision is made for a pen recorder to be connected to the machine. After a relatively short trial period on the teaching machine the aptitude of a person for this type of work can be accurately assessed by examining the pattern of the trace produced by the pen recorder.

While the machine described is designed to train card-punch operators, suitably adapted it could, of course, be used to familiarize operators with other types of keyboard. Recently a prototype trainer has been made that includes the keyboard of an adding machine. The basic principle of operation of this machine is similar,

Interior of display unit showing, on the left, the 96 condensers of the "memory"





Prototype adding machine trainer. Numbers of the exercise are displayed on the six neon tubes

but, because of the different nature of adding machines, a different type of display is necessary and no visual aid in the selection of the correct key is given.

As most people are aware, operation of an adding machine demands that several keys be depressed in sequence to make up a complete number, which is then recorded by pressing an "add" button. Consequently the exercise display consists of six neon number-tubes on which a six-digit number can be shown. The number to be entered on the keyboard is displayed on these neon tubes and the pupil is required to depress the appropriate keys in the correct sequence.

A different method of programming the exercise is used, and the machine is controlled by a perforated tape that is indexed forward a line at a time past a series of electrical contacts. This punched tape determines the numbers to be displayed for the exercise and controls the switching of the required circuits in the machine.

Although a six-digit number can be shown, initially the machine begins with simple groups of three digits. When the pupil is proficient in these, the internal circuits of the machine are altered automatically so that numbers of greater complexity are displayed; for example, more difficult groups of three digits or simple four-digit groups. As the performance of the pupil further improves, so the difficulty of the exercise is progressively increased, stage by stage. Thus, in the adding machine trainer not only is the speed of the exercise increased automatically, but so also is the complexity and length of the lesson.

Other projects that are being developed are a typewriter trainer and a teletypewriter trainer. In the latter case the operator is required to transcribe from audible Morse code signals directly on to the keyboard of a teletypewriter.

It has been intimated that learning machines, even relatively simple ones such as these, can be applied to problems other than teaching. In the factory, such techniques could, for example, be readily used to control the supply of parts to individual operators engaged on assembly work, the number of units supplied to any particular operator being based automatically on the speed at which he is working.

Solartron have been developing these ideas over the past three years. Production of card-punch trainers began in June, 1958, and the first machine was delivered in September.

Filing business data on magnetic tape

Most business data processing systems use magnetic tape for recording the bulk of the information that has to be held on file. The amount of data associated with any individual commercial transaction can vary considerably and means of handling information in quantity that contains records of varying length have had to be devised so that the maximum amount of data can be stored in a given length of tape. Economy in recording data on magnetic tape is essential if computer operating speeds are not to be limited by the rate at which the data can be obtained from the tape.

BY J. F. DAVISON

ELECTRONIC digital computers used for scientific and technical calculations are not normally required to store more than a few thousand numbers and instructions. This requirement can be readily met by storage devices such as magnetic drums or discs, and access can be obtained quickly to the data held, no matter in which particular part of the store it is located. Such devices are called random-access stores and they hold anything from 1,000 to 16,000 words, a word being the generally accepted name of the basic unit of information handled within a computer.

However, when commercial data processing is considered it frequently happens that far more information must be held than can possibly be accommodated by any conventional random-access store. For example, an insurance company may have a million policies, each requiring 30 words of storage capacity leading to a total requirement to store 30,000,000 words. Equally large information storage facilities would also be required for the parts list of a motor manufacturer, since such a list could contain tens of thousands of items, each needing several words storage capacity to accommodate a full stock record and a complete description of the part.

It is for requirements such as these that magnetic tape has been developed as a computer storage medium. It is now made available with most electronic digital computers that are aimed at the business data processing market. As many as 300,000 words can be stored on one reel of magnetic tape and as the tapes themselves are cheap, relative to the overall cost of a computer installation, a store of virtually unlimited capacity can be obtained at a reasonable cost. Magnetic tape is not a random-access storage medium, as the tape has to be read in sequence and generally it takes several

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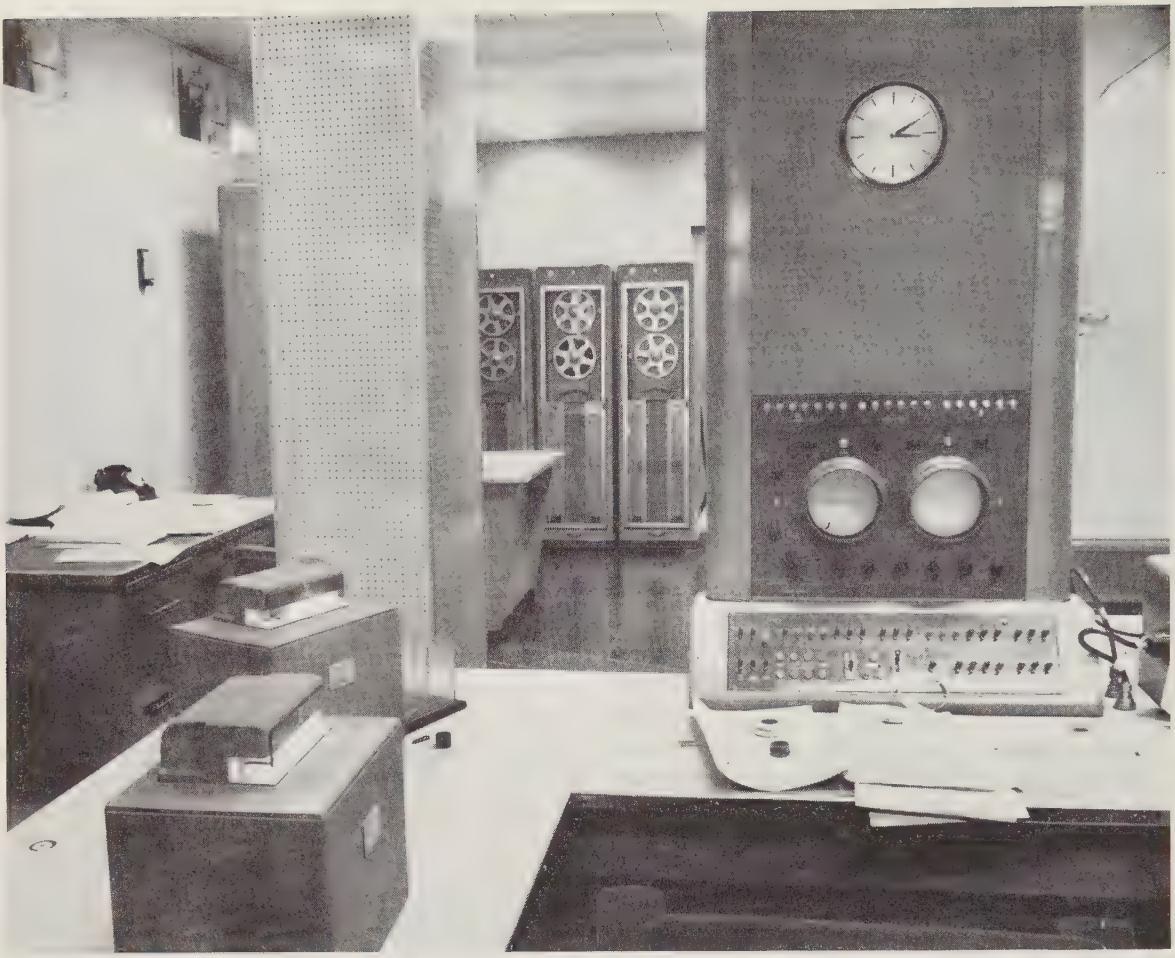
Mr. J. F. Davison is with Ferranti Ltd.

Magnetic tape provides a compact medium on which large quantities of commercial information can be stored. This reel, 10½ inches in diameter, contains 3,000 feet of tape. The punched section is used as a leader when fitting the tape



Babcock and Wilcox have equipped their Pegasus computer with magnetic tape units. These units are fitted principally to enable the computer to be employed on commercial data processing work

minutes to move from one end of a reel to the other, regardless of whether the intervening information is required or not. Nevertheless, magnetic tape is a satisfactory storage medium if the information can be called for in the order in which it is recorded on the tape. For most commercial work it is possible to arrange for this by keeping the information on the tape in some natural order. For example, insurance policies would be held in policy number order, and motor parts recorded in part number order.

If the principle is accepted that digital information can be stored on magnetic tape and read back at speeds which match the operating speeds of electronic computers, the next thing to consider is the arrangement of the recordings made on the tape. Magnetic tape is normally from $\frac{1}{4}$ to 1 inch in width. Between 4 and 16 recording tracks are spaced across the width of the tape and all these tracks can be used simultaneously. Whenever data is being obtained from the tape or recorded on it, known as reading or writing on the tape, the tape must be running at some predetermined fixed speed. Thus for a given magnetic tape system the speed at which information is transferred between the computer and tape is fixed. This fact makes it impracticable to record information continuously along the tape, and the usual practice is to record blocks of information, corresponding to some convenient unit of information handled inside the computer.

The gaps between individual blocks are long enough to allow the tape to be stopped, and for it to be restarted and regain operating speed before the next recorded block of information is reached. Although these gaps must always be present, the tape will in general only stop if the computer does not call for the next block of information immediately, or very soon after it has finished reading or writing the current block. Thus the computer can operate at any speed up to the maximum of the tape.

Most existing magnetic tape systems conform fairly closely to that described so far, but beyond this point there are significant differences. Attention will now be confined to a particular magnetic tape system, that used with the Ferranti Pegasus computer.

Pegasus magnetic tape system

The Pegasus system uses eight-track magnetic tape half inch in width. One track is used for section addresses, that is the code numbers needed to identify particular blocks of data. A second track is a clock track used for synchronizing the operation of the magnetic tape with the computer when reading or writing is being performed. The remaining six tracks are for data, which are recorded on the magnetic tape in a series of rows spanning these six tracks. Each character is defined by the pattern of magnetized spots recorded in the tracks across one row, and consequently is represented by a six bit code*. The Pegasus word has 42 bits occupying seven rows on the tape and the words are handled in blocks of eight inside the computer.

Data may be recorded on the tape in one of two ways in sections consisting of either two or four blocks, that is in sections containing either 16 or 32 words. The latter method uses the tape more efficiently, as fewer stop-start gaps are needed, but the former method gives more freedom to the programmer who has to plan in detail how the computer is to do each job†.

The two methods cannot be mixed on one tape, but it is quite possible to be using both methods at one time on separate magnetic tapes fitted to different magnetic tape units. The number of units included in an installation will vary with the needs of the user, but five or six may be regarded as typical for commercial data processing work.

Automatic checks are performed on all tape operations. Each magnetic tape unit is fitted with a reading and a writing head. As a section of data is written on the tape a check sum is formed of all the characters in it, and this check sum is recorded on the tape as the final character in the section. The reading head, placed just after the recording head, reads the information which has just been written on the tape. Another check sum is derived from this data and compared with the recorded check sum. If these check sums are not identical the tape is reversed and the block re-read. This action may be repeated up to eight times. If agreement still cannot be reached the computer stops. Further attempts may then be made and the fault must be located and remedied before the computer will proceed.

Similar checks are performed on all data read from the tape. As far as the programmer is concerned what this means is that, first, he does not need to include special checks in the programme to confirm the accurate working of the magnetic tape units and, secondly, he can have absolute confidence that errors will be detected not merely eventually, when it may be too late to remedy them, but immediately.

Fitting file records on magnetic tape

When a particular job is to be fitted on to a magnetic tape system, one of the basic questions which must be answered at an early stage is how the main information files are to be held on the magnetic tape. The size of the individual file records is, of course, a critical point. If it happens that this is something just less than either 32 or 16 words one is fortunate and the best policy seems obvious. However, in general, the file record size is not likely to fit the magnetic tape section length so closely and then the following are among the possible solutions.

If the item size is two, four, or eight words in length, an integral number of items can be packed into a section. This does not complicate the work too badly, and is usually a satisfactory solution if applicable. Should the item size be greater than 32 words, two sections, or more if necessary, can be allocated to each item. This will be very wasteful of tape in some cases where, for example, the size of the record only just exceeds 32 words in length.

It is apparent that these techniques will only provide a good solution in a few cases, and they would tend to be very bad where the size varies considerably from record to record. This latter

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*The principles and characteristics of codes used to express data in this way have been described in "The Universal Language of Computing," page 18, *Data Processing*, January-March, 1959.

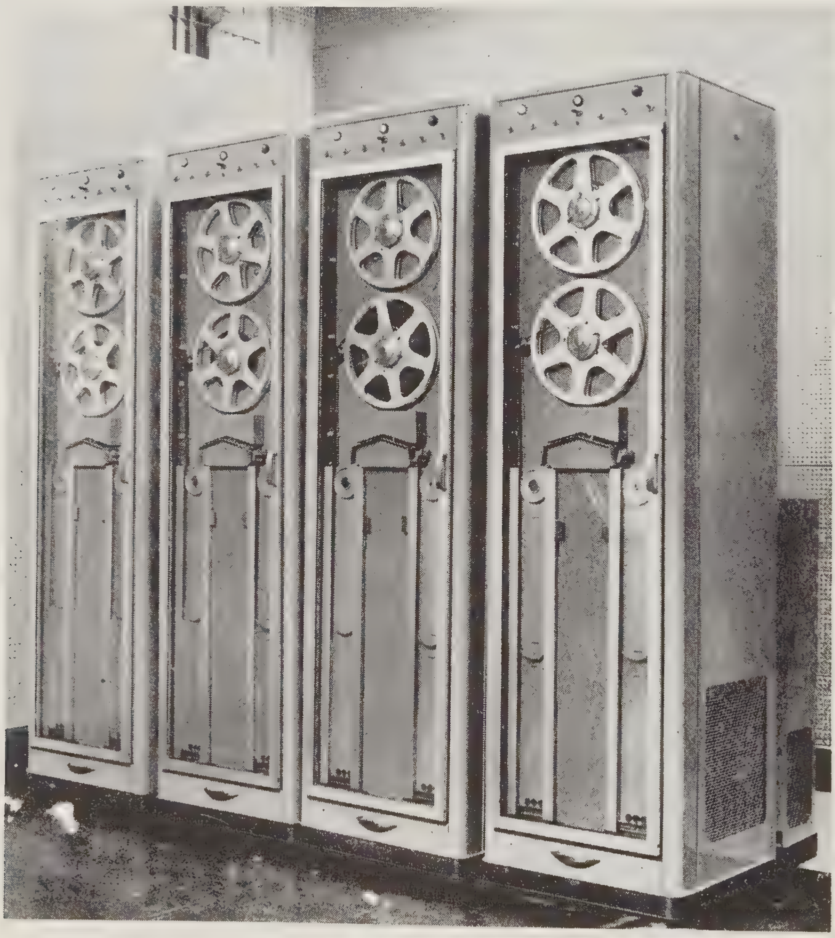
†Programming is discussed in the articles, "How an Electronic Digital Computer Calculates" and "Automatic Programming," both in the January-March, 1959, issue of *Data Processing*.

condition is in fact fairly common in commercial work, and if one still persists with recording data in blocks of fixed length, the length chosen must be such as to accommodate the largest file record handled, with the result that a considerable amount of magnetic tape will inevitably be wasted.

An example of what can happen is shown in the Table opposite where two possible layouts for an insurance policy record are given. One is a fixed-length layout, with spaces left for all possible entries whether applicable or not, and the other assumes that the individual records may be of any length. The form of the record for the purpose of illustration is far simpler than would occur in practice. With the variable-length layout all the space is saved which is allowed in a fixed-length layout for details that frequently do not exist. Some space, however, is lost as each record in a variable-length layout must contain an indicator word, or some similar device, that describes the data that follow. The important point is that in the example, and usually in practice, far more is gained than is lost in terms of space on the magnetic tape. The actual amount of the saving can, of course, only be assessed for specific cases, where the relative frequencies of all the various possible entries in the record are known.

Now to consider how this method is applied inside the computer. On some computers variable-length records can actually be written as such on the tape, in fact the programmer determines how long each section of information is to be. However, there is usually still a restriction on the maximum number of words which can be held in a section. On Pegasus the variable-length records are fitted into fixed-length sections. There is still the choice between 16-

Four magnetic tape units are fitted to the Babcock and Wilcox computer installation. Units can be added as information storage capacity requirements increase. Removal and replacement of a reel of magnetic tape occupies about 1½ minutes



ARRANGEMENT OF A FIXED-LENGTH RECORD

WORD No.	DETAILS OF RECORD	DATA ON TAPE
0	POLICY NUMBER	76453861
1	TOTAL PREMIUM	£45 6 8
2	TOTAL BONUS	—
3	EXISTING LOAN DEBT	—
4	DATE PREMIUM DUE	23/8/58
5	SUM ASSURED	£1,500
6	CASH OPTION	—
7		MR. J. F.
8	MEMBER'S TITLE,	SMITH
9	INITIALS,	—
10	SURNAME	—
11		24, MAS
12	ADDRESS	ON RD,
13	FOR	LONDON
14	PREMIUM	N.E.19
15	NOTICES	—
16		—
17		—
18	LIFE ASSURED'S	J.F.SM
19	INITIALS AND	ITH
20	SURNAME	—

ARRANGEMENT OF A VARIABLE-LENGTH RECORD

WORD No.	DETAILS OF RECORD	DATA ON TAPE
0	POLICY NUMBER	76453861
1	TOTAL PREMIUM	£45 6 8
2	DATE PREMIUM DUE	23/8/58
3	SUM ASSURED	£1,500
4	INDICATOR WORD	abcde
5		MR. J. F.
6		SMITH
7		24, MAS
8		ON RD.,
9		LONDON
10		N.E.19.

The indicator word is split up into groups of bits (some one bit only) that describe the data to follow. It might take this form:

a	Whether Bonus	No
b	Whether Cash Option	No
c	Number of words used for member's name	2
d	Number of words used for address, etc.	4
e	Whether life assured same as member's	Yes

and 32-word sections, but it is generally better to use the latter, as more information can be packed in a similar length of tape. This leads to fewer tapes being required for a given number of file records. Consequently, a smaller percentage of operating time is occupied in rewinding tapes and changing reels.

In practice it is frequently necessary to scan a file of items to locate specific entries, and in these circumstances it would be very awkward and time-consuming if each unwanted record had to be examined in considerable detail merely to be able to ascertain where it ended and the following record began. It is, therefore, desirable to have some straightforward means of recognizing the beginning of each record. There are several possible ways of doing this, but the one adopted for Pegasus is as follows. Every word is preceded by a sign bit which indicates whether it is positive or negative, and words which begin a record are made negative while all other words in the record are positive. It is then very easy to scan through a file, looking at every word in it, and recognizing the first word in each record by the fact that it is negative. Although at first sight this procedure may appear time-consuming it does not slow down the tape-reading speed by very much.

If the recognition and scanning of file records in this manner had to be programmed as part of each job undertaken, this method might well turn out to be impracticable as it would put a very heavy burden on the programmer. However, it is quite feasible to deal with most of the extra work involved by means of standard unit programmes, known as sub-routines. A sub-routine is a short programme devised to perform a particular standard procedure that will be required repeatedly.

Types of commercial work

On considering the type of work which is going to be carried out on these files, most commercial applications appear to be of two types, either sorting or updating files.

In sorting, either new records outside the system require to be entered, or it is necessary to rearrange the whole of, or extracts from, an existing file. At this stage it is necessary to introduce a further convention, that the keyword (e.g. policy number or part number) shall be the first word in each record. The keyword is thus marked with the negative sign bit mentioned previously.

There are several possible sorting techniques on a magnetic tape computer system, but one of the most popular is the merge-sort method. On Pegasus this involves filling the main store (magnetic drum) with as many records as possible, sorting these into order and then copying them out on a magnetic tape. This sequence is repeated until all the records have been dealt with; then the strings of records on the tape are again sorted by the computer and merged to make one long continuous string.

The standard programme used for this task is not as fast as the tape transport speed, but runs on average at about 70 per cent of this

Control console for the magnetic tape units contains a buffer store that holds data until either the computer or a magnetic tape unit is ready to receive them

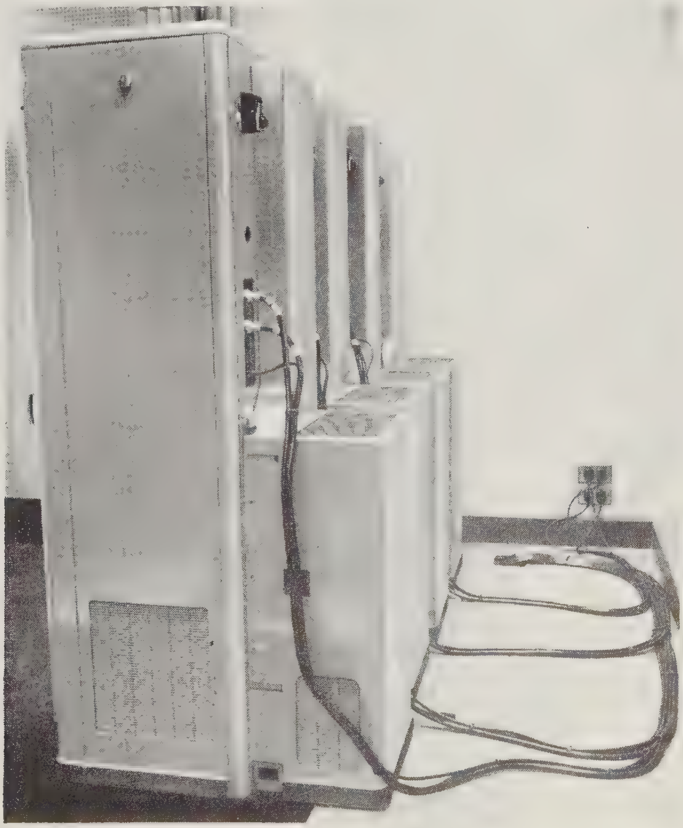
speed. Consequently, if the records are stored on the magnetic tape in fixed-length form, then should 30 per cent of the tape be empty, sorting speed will be limited by the rate at which data can be obtained from the tape. In contrast, should the variable-length method of recording data on the magnetic tape be used, the sorting speed will be limited only by the rate at which the computer programme is performed. This figure of 30 per cent then is the point at which it becomes economic to use the variable-length method of recording data to be held on a magnetic tape file.

Updating files can be a very complicated job, but the essential features are simple. There is a main file of individual records on magnetic tape, in keyword order, and a set of amendments, usually also on tape, sorted into the same order. Not all of the main file records will require to be amended, but occasionally there will be more than one amendment per record. The main file and the file containing the amendments are scanned concurrently, unamended records being copied directly on to a third file that will constitute the new updated main file at the end of the operation. Records having a corresponding amendment are altered and are then written on to the new main file. The actual amendment process will vary from job to job. For instance, in insurance work the payment of premiums on policies may have to be noted, or in stock control work the job is to deduct or add units to the record of the stock held according to the works advice notes and to test for stock warning levels. That is if the stock held should fall below a predetermined level warning must be given. Nevertheless, the organizational work connected with the reading of the original and amendment files and writing out on the new main file is common to all work of this character, and it is well worth while to provide a general-purpose master programme for this task. The programmer responsible for the particular job then produces a subsidiary programme, for inclusion in this master programme, which actually makes the required type of amendment once coincidence between the keywords of the original file record and the amendment file has been obtained. The master programme developed for Pegasus also deals with many more possible complicated situations such as providing for the case where an amendment item has a keyword not on the original file, inserting and deleting items on the main file and so on.

As with sorting, for most of the time the programme for updating files runs at less than maximum tape speed; and this figure also happens to be 70 per cent. Thus, similar arguments apply as to the point at which variable-length working becomes economic.

In assessing the value of variable-length working, account has been taken up to now only of the computer time required for running the programme. A further very important consideration is the saving that can be made in preparing the programmes. There are several possible sorting techniques, some being more appropriate if the data are already partially sorted. Thus, if a separate programme had to be prepared to cater for each of a wide range of fixed-record sizes (say 2, 4, 8, 16, 32 and 64 word items) the task of programming might become overwhelming. Even if the programme required for handling records of variable-length is not quite as efficient as a programme for handling fixed-length records it may still be preferable to use the variable-length method to reduce the burden of programming work. Only one programme would be required for variable-length working instead of, for example, the six needed to cover the range of fixed-record sizes just quoted.

The variable-length method also gives more freedom in planning how a job should be tackled. For instance, it might happen that some obvious approach to a particular job requires a file consisting of some long items and some short ones, involving say 32 and 4 words per record respectively. To allocate 32 words storage capacity for the short records would be very wasteful of tape and also of computer time. Preparation of the special programmes needed for dealing with a mixture of 32 and 4 word items would also be expensive. Thus in the end the job might have to be tackled in some less satisfactory way. This dilemma can be avoided altogether if variable-length working is adopted as the standard method of doing the job and consequently is available from the outset.



Cleanliness is of the greatest importance. Each magnetic tape unit is fitted with its own air filtering and conditioning equipment

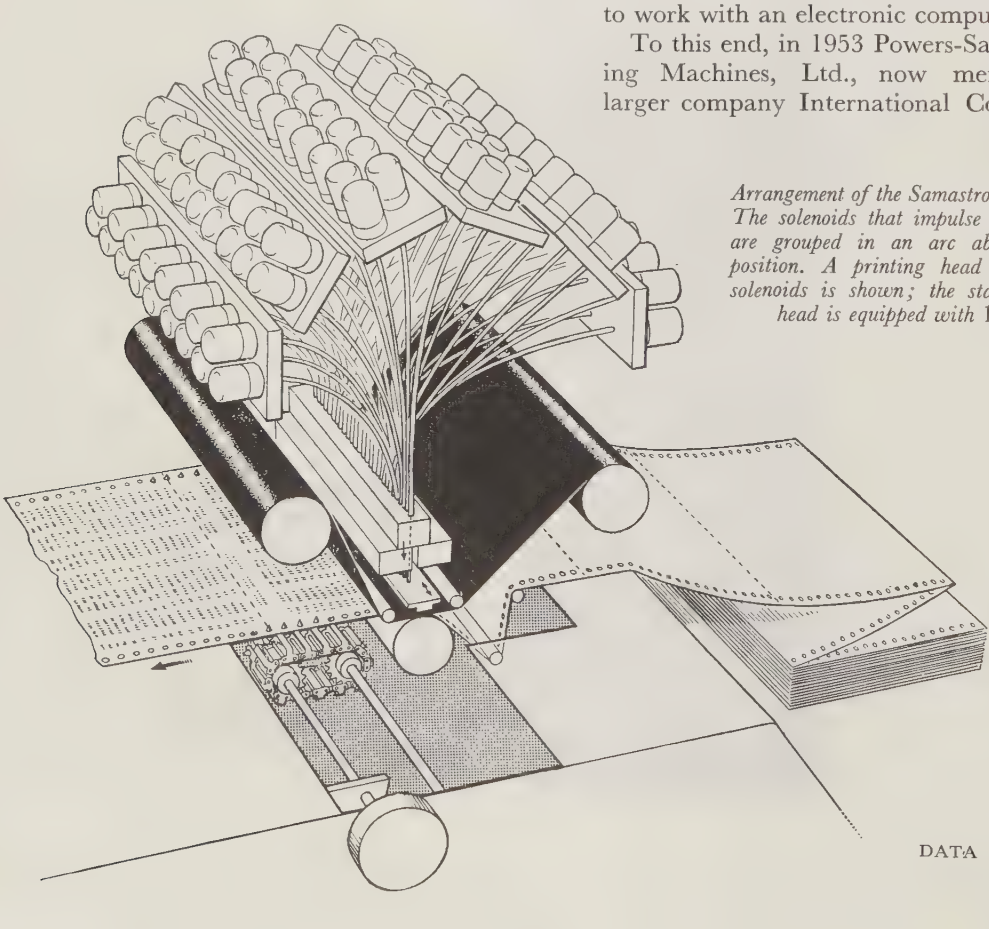
Rapid production o

Printing data by styli at 300 lines a minute

Each line printed by the Samastronic can be up to 14 inches in length and contain 140 characters. A range of 50 characters or symbols can be printed. The Samastronic printing head has also been included in a new design of high-speed punched card tabulator. This machine can read standard 65- or 80-column punched cards at 300 a minute and prints the data directly on to continuous stationery that may be of any width from $3\frac{1}{4}$ inches to $18\frac{3}{4}$ inches. Sterling and decimal data can be handled and the tabulator is equipped with seven adding registers of 10 digits capacity on which sub-totals, totals and grand totals can be summed. Adding registers of greater capacity, 13 digits, can be supplied. An unusual feature is a phrase-printing device.

OFTEN, speed of printing limits the volume of work a data processing installation can handle. This is especially true of commercial work where considerable numbers of documents are required. An obvious method of speeding up printing is, of course, to use machines that print a complete line at a time, in contrast with one character at a time. For this reason all the early electronic digital computer installations engaged on commercial work made use of an existing item of punched card machinery—the tabulator. While as inferred, this prints a complete line at a time, the speed is still relatively low—of the order of 80 lines a minute, and something faster is needed to work with an electronic computer.

To this end, in 1953 Powers-Samas Accounting Machines, Ltd., now merged in the larger company International Computers and



Arrangement of the Samastronic printing head. The solenoids that impulse the printing styli are grouped in an arc above the printing position. A printing head fitted with 102 solenoids is shown; the standard production head is equipped with 140 solenoids

commercial documents

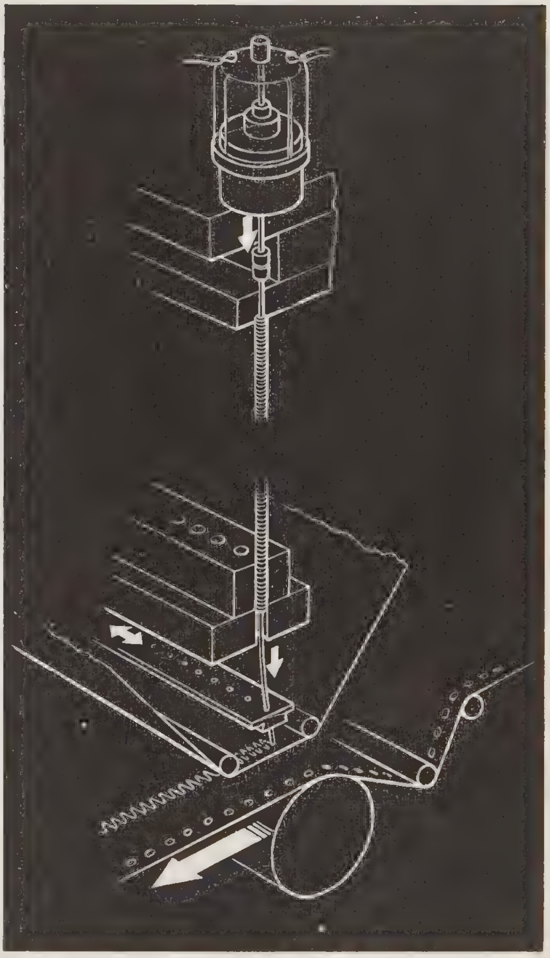
Tabulators, Ltd., started work on a new high-speed line printer. This is now in production and has been given the name Samastronic. It is solely a printing machine and, as such, it is connected to or built into other data processing equipment. Its two principal applications are as a high-speed output printer for electronic digital computers or, in a conventional punched card installation, as part of a new high-speed tabulator known as the Samastronic tabulator. Another version of the printer that is built for computer data processing installations operates independently of the computer (off-line operation) and converts into print data recorded on magnetic tape.

With the Samastronic printing head, a range of 50 characters can be printed at any, or all, of 140 positions—this number gives a line 14 inches in length. At maximum speed the head prints 300 lines a minute. Character spacing is the same as that commonly used in typewriting, ten characters to the inch. Of the group of 50 characters for printing, six may be specified by the user; the remaining 44 comprise the alphabet, decimal figures and certain fractions and arithmetical signs.

Printing technique

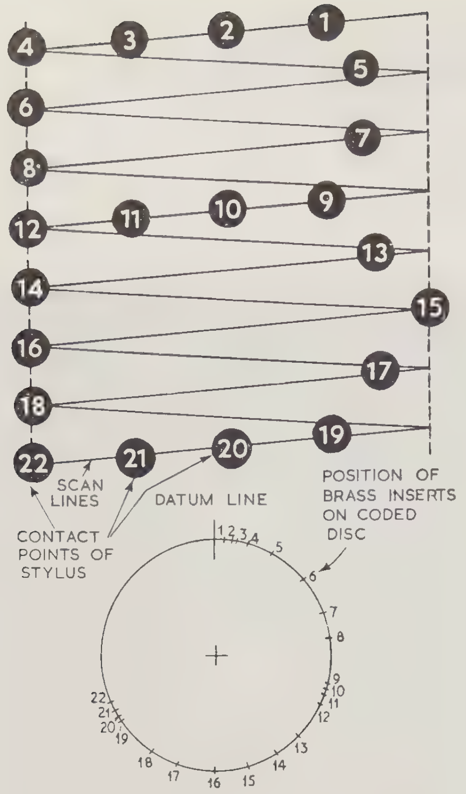
In order to print at these speeds a new printing technique was evolved. Each character is formed by a large number of individually printed dots that overlap. These dots are printed by a reciprocating stylus that moves over the area where the character is to appear.

The paper is wound over a roller, and between the paper and the printing stylus is threaded a carbon ribbon. As the stylus impinges on the ribbon so a dot is printed on the paper underneath. The ribbon is over 14 inches in width and is made from a fabric impregnated with carbon. Two movements combine to enable the stylus to delineate the character to be printed. One is provided by the paper-feed mechanism. Paper is fed past the printing head at a steady rate by two chain and sprocket drives which engage with the perforations down the sides of the continuous paper stationery. The other movement is obtained by the stylus travelling from side to side.



Detail of solenoid-operated printing stylus. The zig-zag path traced out by the stylus is shown

There is one stylus for each of the 140 spaces in the line. They are supported at their extremities by jewelled bearings fitted in a bar which is reciprocated through a distance of 0.08 inches in a direction at right angles to the paper-feed. Consequently each stylus traces out a zig-zag path over the paper. The path taken is shown in the illustration above. Fifteen passes are



Impulses given to a stylus when printing the letter B. In the lower diagram is shown the disposition of inserts in the disc to produce these impulses. Figures refer to the order in which the impulses are transmitted and the dots printed

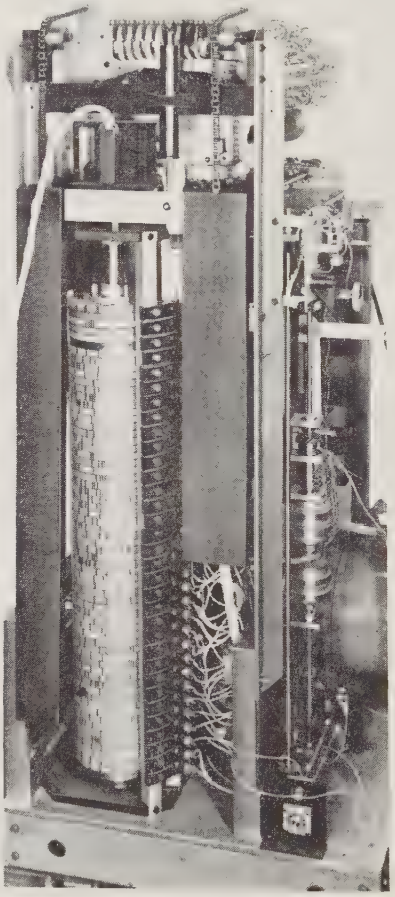
made over the area occupied by a character. As it follows this path, the stylus receives a series of impulses at the points necessary to portray the required character and, to the eye, a reasonably uniform and continuous image of the character is produced. A character, and in fact the entire line, is printed in 1/5 of a second. The illustration above shows magnified the positioning of the dots to make the letter B.

A solenoid is used to provide the impulses. Because the solenoids are relatively large they have to be grouped in an arc above the reciprocating bar and operate the styli through flexible cables. The signals that energize the solenoids at the correct times are received from coded discs via a decoder unit.

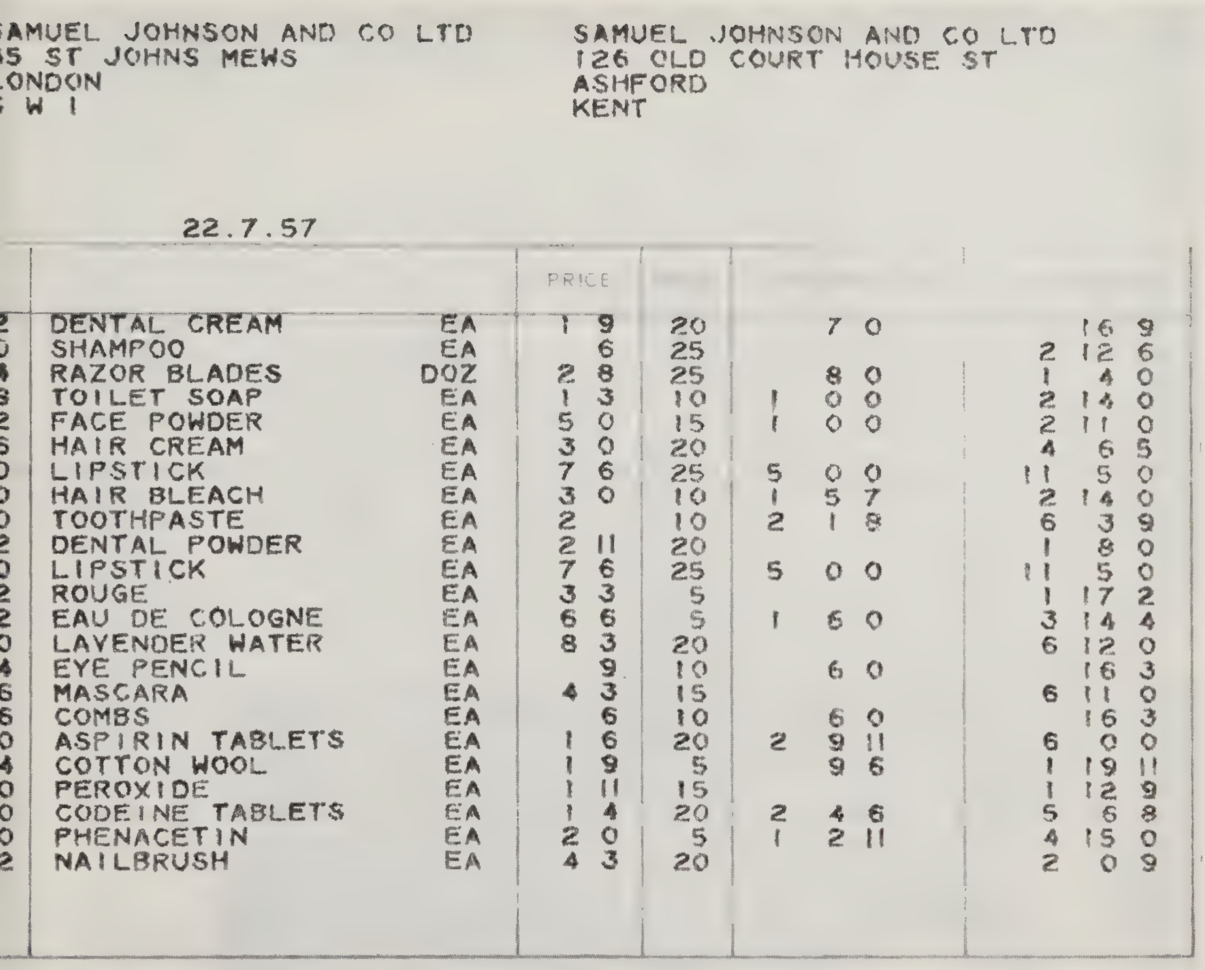
At the rear of the machine is a large drum made up of a stack of 50 separate coded discs. All the time the printer is in operation this drum revolves at a constant speed of 300 revolutions a minute. Each disc, made from an insulating material, represents one of the characters that can be printed by the machine. Brass segments are set round the periphery of each disc. A carbon brush makes electrical contact with the edge of the disc and as each segment passes underneath the brush so an electrical impulse is transmitted. Pulse signals from all the 50 discs are sent to a decoding unit.

Decoding unit

The purpose of the decoding unit is to select the appropriate pulse train according to the information read from the card so that the correct character is printed. For example, a line of 140 A's might be required, in which case the signal received by the decoder from the coded disc A would be sent to all the 140 solenoids. The disposition of the brass inserts round the disc for the letter B is shown on the left.



Assembly of coded discs. This unit rotates at 300 revolutions a minute



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DENTAL CREAM	EA	1	9	20		7	0		16	9
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RAZOR BLADES	DOZ	2	8	25		8	0	1	4	0
TOILET SOAP	EA	1	3	10	1	0	0	2	14	0
FACE POWDER	EA	5	0	15	1	0	0	2	11	0
HAIR CREAM	EA	3	0	20				4	6	5
LIPSTICK	EA	7	6	25	5	0	0	11	5	0
HAIR BLEACH	EA	3	0	10	1	5	7	2	14	0
TOOTHPASTE	EA	2		10	2	1	8	6	3	9
DENTAL POWDER	EA	2	11	20				1	8	0
LIPSTICK	EA	7	6	25	5	0	0	11	5	0
ROUGE	EA	3	3	5				1	17	2
EAU DE COLOGNE	EA	6	6	5	1	6	0	3	14	4
LAVENDER WATER	EA	8	3	20				6	12	0
EYE PENCIL	EA		9	10		6	0		16	3
MASCARA	EA	4	3	15				6	11	0
COMBS	EA		6	10		6	0		16	3
ASPIRIN TABLETS	EA	1	6	20	2	9	11	6	0	0
COTTON WOOL	EA	1	9	5		9	6	1	19	11
PEROXIDE	EA	1	11	15				1	12	9
CODEINE TABLETS	EA	1	4	20	2	4	6	5	6	8
PHENACETIN	EA	2	0	5	1	2	11	4	15	0
NAILBRUSH	EA	4	3	20				2	0	9

Part of a document—reproduced here full size—printed by the Samastronic at 300 lines a minute

Both the insert and the associated dot it produces on the document are indicated on the drawing by identical numbers. The gap between the last insert 22 and the starting position for the disc is the allowance for the space between the printed lines.

Normally, data are printed at six lines to the inch, but by varying the speed at which the paper is fed through the machine, other line spacings can be produced. As standard, machines are supplied to print at either six or eight lines to the inch. Maximum depth of individual forms is 16 inches. Vertical spacing of the lines on the document is controlled by a paper feed wheel. A different wheel is needed for each type of document produced and these wheels can be quickly changed by the operator.

Two separate reels of continuous stationery can be fed under the printing head simultaneously at different speeds by means of a special double feed mechanism. When this unit is fitted it is possible to print lists on one reel of paper and sub-totals and totals derived from these lists on the other reel.

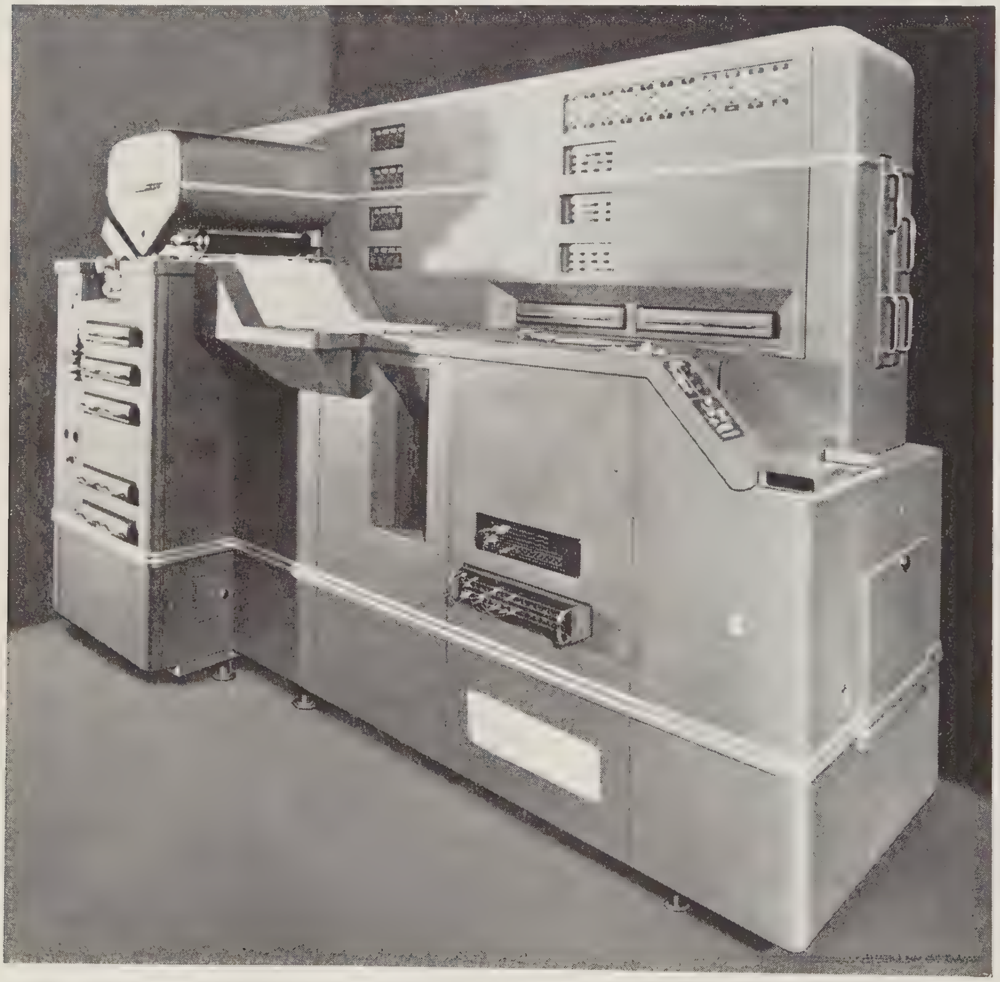
If stationery interleaved with carbons is used, up to three copies can be produced at the same time. Also, of course, by supplying identical signals to two sets of solenoids simultaneously, it is possible to produce duplicate copies of the same data side-by-side—that is, if the two lines are less than 70 characters in width. For example, an invoice can be printed on the left-hand side of the paper and a packing note on the right, both containing similar information.

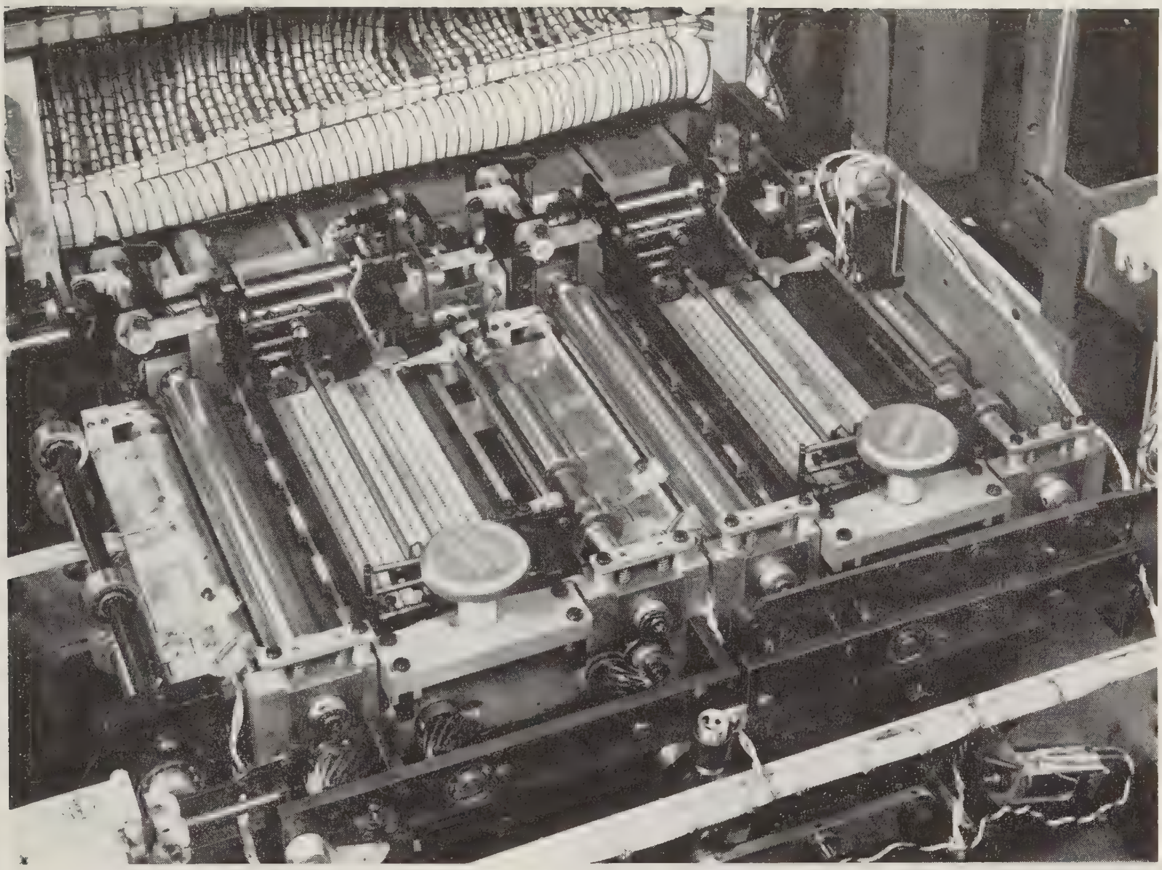
This, then, is the Samastronic high-speed printer. As has already been mentioned, it may be used connected directly to a computer or included as the printing unit in a high-speed tabulator. The printer itself costs £10,000 and the Samastronic tabulator into which the Samastronic printing head is built costs about £20,000.

The Samastronic tabulator possesses all the standard features of a tabulator: that is, data appearing as punched holes in cards are translated and printed directly on to the appropriate documents, but this machine has the advantage that it performs this work at a much higher speed. Standard 65-column or 80-column punched cards are read at a speed of 300 a minute. Since the printing rate is also 300 lines a minute, the data for one line are carried on one card. However, it is possible to print more than one line for each card handled or, alternatively, to print one line from data read from two or more cards. Either of the two paper feed speeds can be selected, so there can be either six or eight lines to the inch.

Cards to be tabulated are placed in a hopper at one end of the machine and from there they are fed in sequence to the first reading station. Data are read from the cards mechanically by pins which penetrate the holes and close electrical switches. At this first station, data are read from one section of the card, usually the upper three rows that specify how the information punched in the remainder of the card is to be interpreted and for what purpose it is to be used. Control holes in these positions regulate the feeding of the paper and similar functions.

The Samastronic high-speed tabulator reads punched cards at the rate of 300 a minute





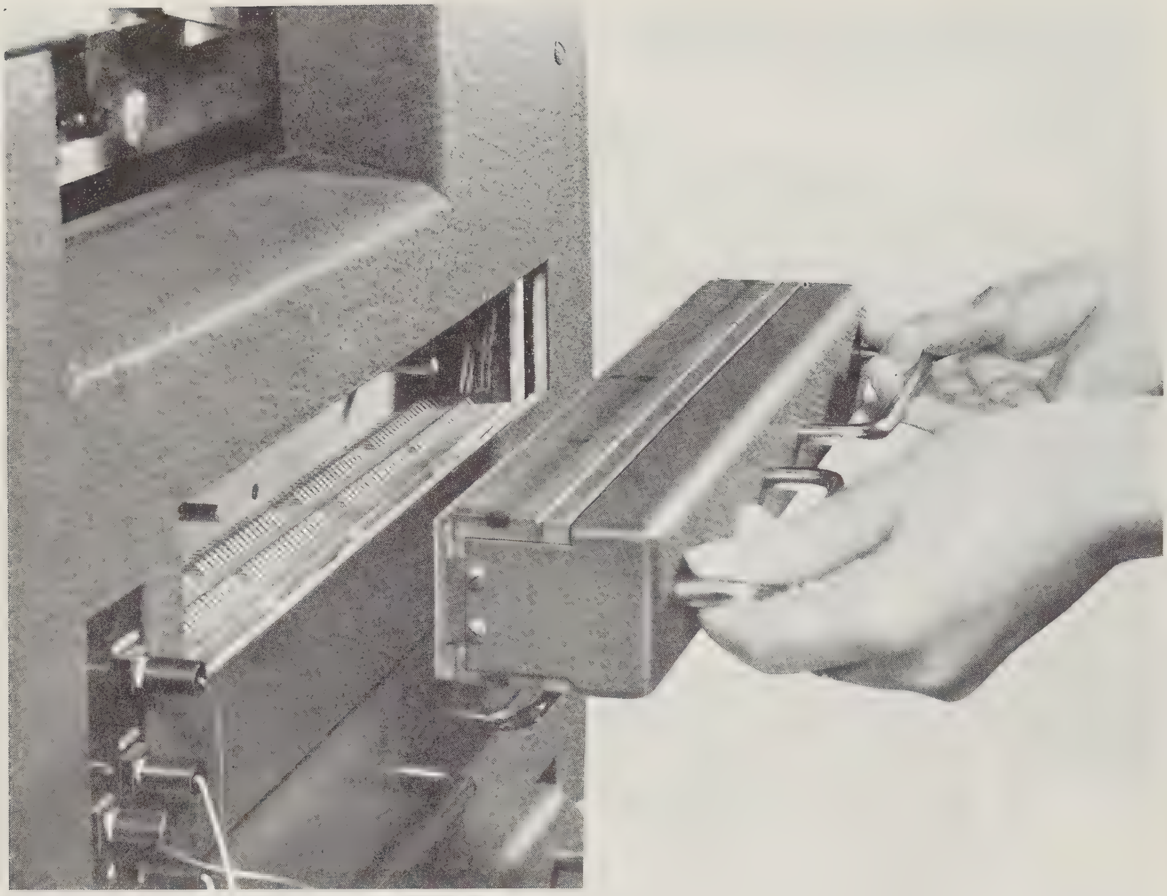
(Below) Either three or six additional adding registers housed in this cabinet can be connected to the tabulator

(Above) Data are read from punched cards at these two stations in the Samastronic tabulator

The card now passes to a second reading station and here the remainder of the data entered on the card are read and printed out on the document in the correct positions. Data contained on a card are generally numerical, but alphabetical characters can be entered if required to provide identifying information.

Seven adding registers are fitted to the tabulator; on these totals and sub-totals, negative or positive, can be summed. Checking circuits operate in conjunction with the adding circuits to confirm correct functioning.

Additions or subtractions from the totals in the registers can be made—subtraction being indicated by a hole punched in a special position in the card. If required, additional registers can be operated by the machine, provision being made for a cabinet containing either three or six extra registers—decimal or sterling—to be connected to the tabulator.

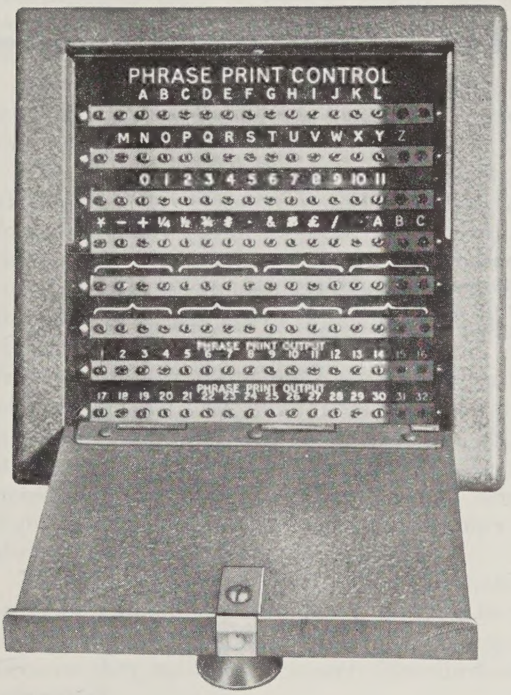


Operation of the tabulator is controlled by connection units that can be changed easily and quickly

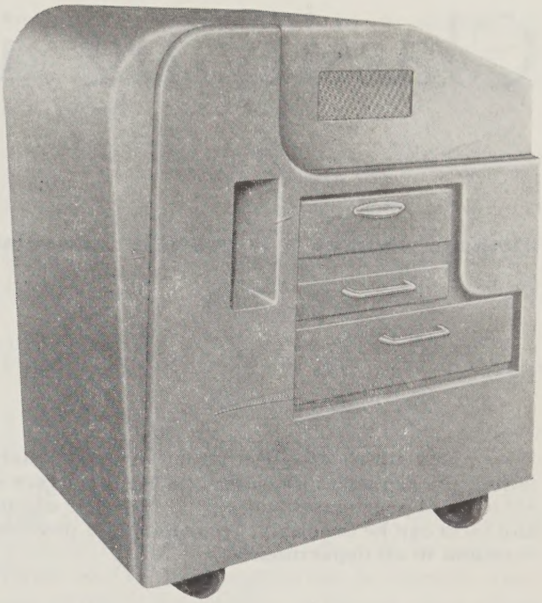
The registers are made as plug-in units and each register has a capacity of ten decimal digits. Larger registers with a capacity of 13 digits can be fitted or, for accountancy work, the decimal registers can be changed for sterling registers. A signal lamp on the control panel for each register indicates whether the particular register is operating correctly. Should a fault develop in a register, the tabulator will stop automatically, whereupon the faulty unit can be unplugged and replaced.

From an operational point of view the Samastronic tabulator is more flexible than the majority of existing tabulators because provision is made for adding sub-totals to produce grand totals, also items appearing in one line can be cross-added and the total printed in the end column of the same line. Electrical connection units fitted to the tabulator control various aspects of the machine's operation. A connection unit is an easily removable plug-in unit that contains a number of permanently wired electrical junctions. When a connection unit is plugged in, it interconnects electrically the many internal circuits in a certain order, so that the machine will perform the particular work required of it. If another job or, maybe, a card of different design is to be handled which requires the circuits to be interconnected in a different way, it is merely a matter of plugging in another connection unit.

One of the principal purposes for which these units are used is to specify where the data read from a particular position on the card, or accumulated in the adding registers, are to be printed on the document. Four connection units, each giving a different printing layout, are fitted to the Samastronic tabulator. Which connection unit is to be used for a particular card is part of the data read from the card at the



Phrase-printing panel on which complete sentences of up to 32 *characters in length can be constructed*



A summary card punch can be connected to the tabulator

first sensing station of the machine. Other connection units are used to select from each card the data that is to be sent to the various summing registers to be totalled.

Many special units for performing specific tasks can be built into the tabulator. One is an automatic totalling attachment. A pack of cards being tabulated may consist of several separate batches for which individual totals are required. If each batch of cards is given a different code number and this code number is reproduced in all the cards of one batch, a change in code number occurring between adjacent cards obviously indicates the end of one batch and the beginning of the next. This situation is detected by the automatic totalling attachment, and the total compiled in any one or all of the registers relating to the batch just completed will be automatically printed out. Another useful accessory is the phrase-printing panel. By selecting and electrically interconnecting holes in the panel with jack plugs, the operator can construct any phrase up to 32 characters in length. When a hole is detected in a card in a special position a complete phrase will be printed out automatically. Examples of such phrases are, "This week you have a tax refund," "Balance owing is shown in last column," or shorter ones such as "Goods value," "Purchase tax" and "Amount payable."

A unit that can be coupled temporarily to the tabulator is a summary card punch. This unit will punch a card every time a total or sub-total stored in one of the registers is printed out. The unit will also punch in these summary cards any associated alphabetical descriptions or numerical codes needed to identify the data.

Other applications

The Samastronic tabulator represents a notable advance in tabulator design if only because it operates three times as fast and can print lines almost twice as long as those produced by conventional tabulators. Definition of the characters is, of course, not perfect compared with type; nevertheless, it is clear and legible. The Samastronic high-speed printer by itself is also proving popular as an item of auxiliary equipment in comprehensive computer data processing systems produced by other firms.

Classifying information

Methods whereby it is possible immediately to trace any item or fact that is required

How many times does the situation arise where information known to be within the organization cannot be found? Every such instance is, of course, evidence of poor classification. This article discusses means whereby items and facts can be concisely, accurately and positively identified in a language common to all departments.

BY V. H. MANSELL

EXAMPLES of the type of trouble a good classification and coding system can avoid are easily illustrated. An urgent order is held up for want of material. Is there a suitable alternative in the stores? Unless a quick and simple means of identifying the material is available the answer to this question probably cannot be obtained. As an indication of the complexity of this apparently simple problem, the same material polyvinyl chloride is commercially available under the following proprietary names: BX.PVC, Capovin, Corvic, Craylene, Duraplex, Erinoid PVC, Flexatex, Ken-u-tuf, Koroseal PVC, Li-Lolastic, Marvinol, Periflex, Rilene, Vinatex, Vinylite, Welvic, and this is by no means a complete list.

Similarly, when a new product is being designed does the drawing office examine all existing comparable drawings to establish whether components already designed, and their tools, can be used in connection with the new product? More often than not each drawing will be detailed anew without regard to previously designed components because it takes too much time to locate existing old drawings.

Classification is also, of course, a necessary prerequisite to the mechanization of accounting operations. Book-keeping, accountancy decisions and the maintenance of ledgers—the larger and more complex the business the more pieces of paper and entries to be handled. Frequently it is found that diverse individual methods of identifying data are preventing the integration of information in a common system and, consequently, also preventing mechanization of that system.

It is commonplace that, with a logical classification system, the code numbers by which customers are identified can be made to convey information about the customer in addition to providing an identification. Using such a technique, an insurance company, for instance, can easily select samples relating to any particular type of policy and risk.

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There are many classification and coding systems in existence. Those of the "universal" kind used in libraries represent a necessary part of the organization of library information, the entire recorded world of knowledge being both their scope and content. These codes, however, comprised of parts of varying length, are too long and therefore unsuitable for application outside library work.

For business and industry, classification systems need not be so wide in scope, the main task being to classify "items" and "facts."

The operation of reducing the description of an item to a numerical symbol is, in its simplest form, the allocation of a number to a recorded description of the item, with each additional item numbered in sequence. Little or no thought is required to inaugurate such a system: the reference numbers represent the registration of items in the chronological order of their occurrence. But this numerical value neither describes the item in a manner in which its recurrence can be detected, nor does it achieve a rational arrangement of items. Further, the method relies upon the memory of the individual allocating the numbers.

While it is accepted that certain information must be sequentially numbered, business items and facts do not generally fall into this category because they must be accurately identified and controlled.

Qualities of a classification system

What are the qualities a good system must possess? First, the scope of classification must be established and correctly defined. Obviously, too, each item must be accurately identified from the user's point of view so that all descriptions are technically correct and sufficiently complete. Next, all items must be classified so as to bring similar items together according to those features which are permanent and important. When this is done, duplication can be eliminated because closely similar items can be revealed for consideration as alternatives and equivalents.

Whatever classification system is designed, it must cover the full range of items, leave sufficient room for expansion, and ensure that all headings are fully, accurately and individually descriptive, thereby avoiding the use of such imprecise terms as "Miscellaneous," "Sundry" and that much overworked abbreviation "Etc." The following is an example of how the scope of a classification system is established and, bearing in mind the points mentioned, broken down into its constituent elements. If we consider a manufacturing firm, production is achieved

0	by	organization, men and operations
1	from	primary materials
2	and	commodities, items bought out but not design controlled
3	into	components, design controlled
4	and	sub-assemblies and assemblies, design controlled
5	by means of	tools and portable equipment
6	and	machine tools and production plant
7	with the help of	services and utilities
8	leaving	scrap and waste

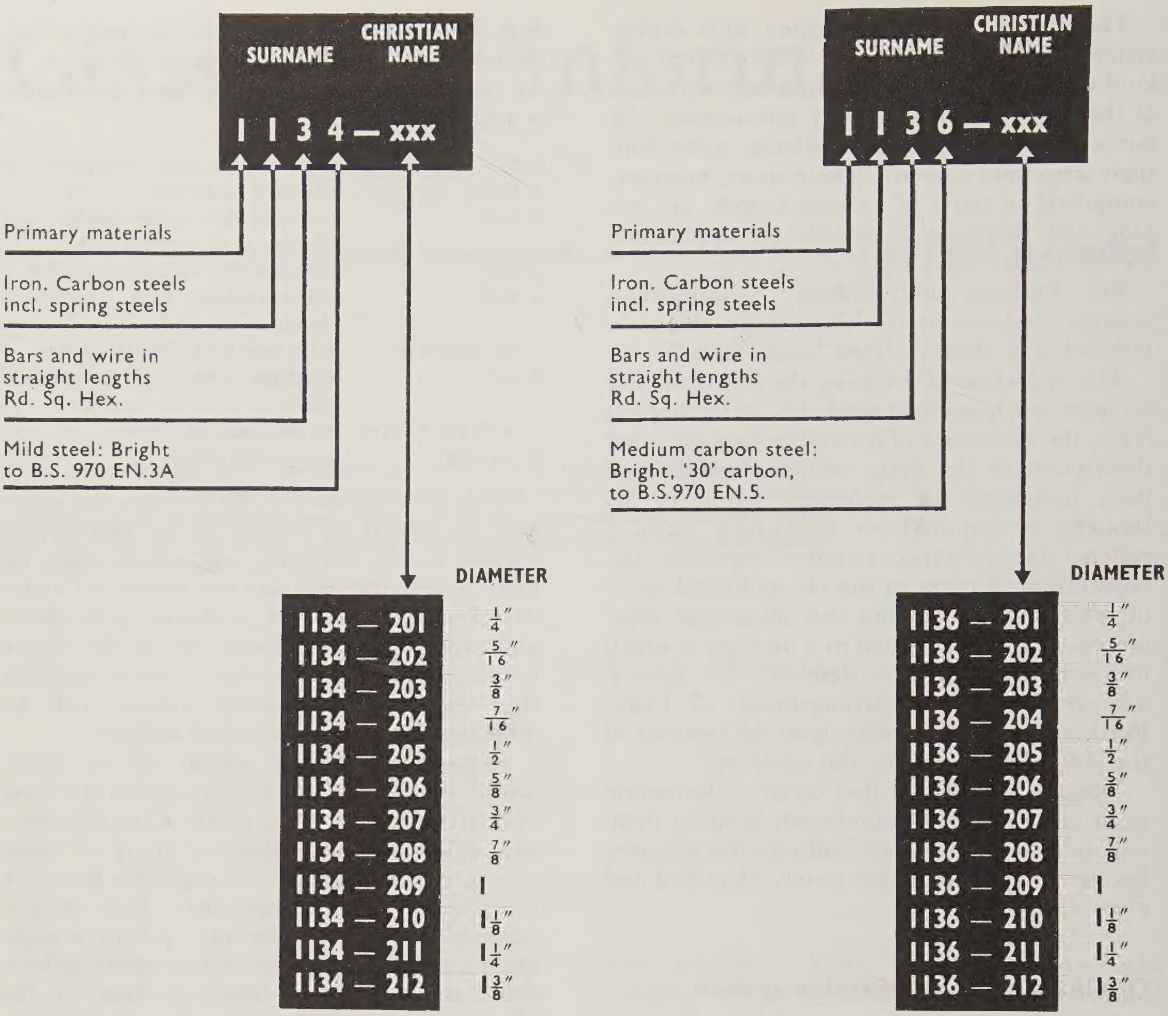
Such a breakdown as this defines the scope and all aspects of interest to an engineering manufacturing company. As will be seen, all items used in the company can be entered under one of the nine headings, or classes, given above and each class is identifiable by the first figure in the code number. For other types of company the scope and definitions chosen will be different, but the principle still applies.

A good classification system will be represented by a numerical code in which the form of notation reflects the pattern of the classification structure. Each digit or group of digits represents the classified characteristics by virtue of value, position or sequence. Each item is identified by one number only. Adequate room exists for the introduction of new items without the fear of the code breaking down or the disruption of the systematical layout of the classification. The length of the code number is constant and consists of two parts, sometimes referred to as the surname and the christian name.

It has been confirmed by users of digital computers that an industrial code of the form "surname, christian name" is of great practical value for all normal data input and output operations. Characteristics of greatest significance are recorded in the surname and lesser identifying details in the christian name.

Two examples of a classification code of this type given in the table on the next page illustrate the principles discussed.

Economy in storing this information in a computer, or presenting it at the input stage, or printing it at the output stage, can be achieved by handling the data in "strings," where each string is identified by the code used for the surname and all the separate items are identified only by their christian names. Thus data con-



A classification code of the surname, christian name type. With a logical classification code the actual number used to identify an "item" or a "fact" describes its most important features. For instance, the christian name 209 *means round,* 1 *inch in diameter*

cerning primary materials would be handled in this manner: 1134—201, 202, 203, 204, or 1136—201, 202, 203, 204, and so on. By using this technique the load on data storage capacity and output printing is reduced by approximately one-third.

From the foregoing the salient points of a good classification system are apparent. It will be noted that the same digit, or group of digits, in the same position in any code number indicates the same characteristic. For example, the 3 in both surnames represents "Bars and wire in straight lengths, round, square, hexagonal." Similarly, the christian name 209 in both the numbers 1134—209 and 1136—209 means round, 1 inch diameter.

Consequently, with a good classification system it is possible to select all those items possessing a similar characteristic although this characteristic is not one of the main ones covered in the surname.

With or without electronic data processing, the logical classification of items and facts gives "the rules of the game" so necessary for the production of order throughout a system or organization. It is a fact that many data processing systems have been severely hampered in the past by the lack of good reliable classification of the information to be handled. In addition, bad classification can lead to data processing equipment of far greater capacity being required than is really needed.